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KNOWLEDGE

AN ILLUSTRATED MAGAZINE OF SCIENCE LITERATURE & ART.

Founded by RICHARD A. PROCTOR.

"Let Knowledge grow from more to more."
—TENNYSON.

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ANIMAL WIND-BAGS—USEFUL AND ORNAMENTAL.

WIND-BAGS AND LOVE-DISPLAYS.

By W. P. PYCRAFT, A.L.S., F.Z.S., ETC.

IT is astonishing, when one comes to reflect on the matter, how many and quite unrelated animals have adopted the same tactics, though by very different means, to gain some particular end, whereby they may obtain some advantage over their neighbours in the struggle for existence. Wind-bags or "air-sacs" of some sort or another seem to have been especially favoured. By their means the form of the body may be temporarily changed, thereby rendering the animal unlike its near allies, but superficially like that of some other creature or even inanimate object, or they may serve as voice organs, whereby their possessors may charm their mates, or strike terror into the heart of an enemy. Yet again, they may serve the purpose of a substantial banking account, and enable life to be got through with the least possible expenditure of energy.

These wind-bags, which, almost without exception, may be inflated and deflated at the will of the animal, differ much in the nature of their origin. In many cases they are formed by more or less extensively enlarging parts of the gullet or of the windpipe, without disturbing their normal functions. In others the air is drawn into special receptacles. Wind-bags of the latter type, however, have also been developed as auxiliary breathing organs, as in the case of birds, for instance. With these we have no concern here; their description awaits special treatment. In the present series of articles, of which this is the first, we propose to deal only with those air-sacs which are concerned with purely external phenomena.

The development of purely ornamental wind-bags, used as adjuncts in courtship, forms the theme of the present chapter. The most conspicuous and successful patrons of this form of display are to be found amongst the ranks of the highly excitable and always beautiful birds.

Thomson's assurance that "the lover is the very fool of Nature" seems particularly applicable to displays of this kind. Take the common pigeon for example. Could anything appear more silly than the strutting, bowing and cooing of the cock aided by this very practice of filling his gullet with intoxicating draughts of the morning air, the which swells his neck to unduly large proportions, and apparently, on this account, make him so much the more fascinating? But the past-master in the art of windy love-making among the pigeons is the domesticated variety known as the pouter.

As with the pigeon tribe, no special receptacle is provided for the indrawn air, but that portion of the gullet known as the crop has been enormously enlarged so that, when fully inflated, it exceeds the body itself in size. The present greatness of this crop, we would point out, is due not so much to the efforts of the prancing bird as to the care and selection of the breeder. For this display, strangely enough, has found favour even among men; consequently, the very finest performers only are selected to be the parents of the next generation, and these parents are themselves, of course, descendants of equally distinguished birds. The part the breeder has played has been to select carefully from his young birds those which prove the best performers. From these he raises new stock. Their unskilled kindred go to make pigeon pie, or meet some other ignoble fate.

A still more remarkable gullet pouch is that of the frigate-bird of the Tropics; a near ally of the cormorants and gannets. Bare externally, of a vivid scarlet colour, and capable of being inflated till it is nearly as large as the rest of the body, this pouch is an invaluable asset to its possessor when seeking a mate. For here, as elsewhere, the successful suitor is he who makes the most of his peculiar charms; the prize falling to him who is able to display the biggest and most brilliantly coloured pouch. Only the males wear this ornament, which is retained only during the breeding season. At this time a lively competition appears to take place, a dozen or so of these birds crowding together in a tree and greeting the approach of their prospective mates with inflated pouches and drooping wings, accompanied by a peculiar apology for a song, described as a sort of "wow-wow-wow-wow," and a noise resembling the sound of castanets, which is made by a violent chattering of the horny beak.

The pouch of the frigate-bird is formed by the upper end of the gullet, and appears to be closed behind by a peculiar arrangement of muscular fibres to form what is known as a sphincter muscle. These muscles close up the tube of the windpipe much as the mouth of a bag is closed by means of a double string.

The American prairie-hen, or pinnated grouse, has long

been celebrated for its remarkable love display. Collecting in small parties of both sexes, the males come forward and perform a series of strange evolutions, in which a pair of sacs, one on either side of the neck, play a conspicuous part. When the bird is quiet these sacs or bags are hidden by the feathers, but during the paroxysms of excitement they are inflated so as to form a pair of huge bladder-like organs, of a bright orange colour. As soon as these pouches are filled certain elongated feathers of the nape of the neck are shot forwards, the wings are trailed upon the ground like those of the turkey-cock, and the body, with the feathers bristling like the quills of the fretful porcupine, is inclined forwards. Suddenly the bird starts to run, rushing in among the amazed females and giving voice at the same time to a loud booming noise, audible, on a still morning, for a couple of miles. Then follows a momentary period of quietude, and the process is repeated. Sometimes as many as twenty cocks take part at a time in these displays.

The depletion of our British bird-fauna which has taken place during the last fifty years has robbed us at one fell stroke of our largest British bird, as well as the only nember thereof which boasted a true ornamental air-sac. This was the great bustard To witness the display of this bird in a wild state to-day one must travel to Spain. To the bird-lover the journey is well worth the making, for a more wonderful, and at the same time a more grotesque sight, would be hard to find, since the inflation of its wind-pouch is accompanied by the art of the contortionist.

Approaching his mate with a series of short, mincing steps, he next proceeds to throw his tail forwards so as to lie flat upon his back, where it is held down by the long quills of the wing. Thus he contrives to display a magnificent, billowy mass of white feathers which normally lie under, and are concealed by the tail. Next he ruffles up the feathers of the back and wings in such a way that certain feathers forming the inner lining of the wing are brought prominently into view; these also are white as the driven snow. Finally the head is thrown back, and the wind-pouch or air-sac as it is called, is inflated to an enormous size, almost burying the head therein This done, the head is still further masked by the erection of a number of long feathers, which normally, when the bird is at rest, hang down like a long beard. Erected, they stand up on either side of the head like a

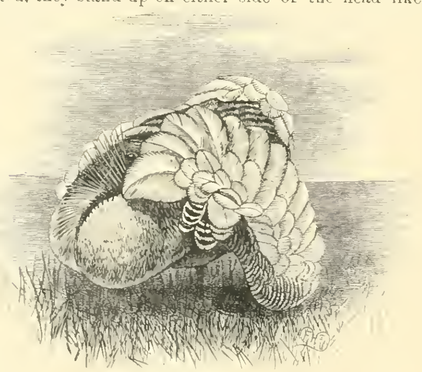

FIG. 1.—The display of the Great Bustard, *Otis tarda*. (After Wolf.)
From the "Dictionary of Birds," *by* PROF. A. NEWTON.

palisade. What the general effect of such a display is like may be gathered from the annexed picture.

This air-sac deserves further notice, for it is a peculiarly interesting structure both from an anatomical and a historical point of view.

Well known to the older naturalists, it was generally regarded by them as a receptacle for water, a view which gained colour from the fact that the bird frequented arid and sandy wastes where water was naturally scarce, so that the possession of a water-bottle seemed by no means a striking feature. This tradition, in more critical times, first became suspect by the discovery that the male only possessed the pouch. Further enquiry showed that not even all the males were so provided, and this led many to believe that the whole story of the existence of the pouch at all was a myth. If its use was to store water, they contended, it should be found in both sexes, since both would have equal need thereof. The fact that many adult male birds had been dissected without revealing the presence of a pouch seemed to confirm their doubts as to the probability of the story.

Later observation, however, has definitely settled the question. Careful dissection has proved the existence of the pouch, whilst the field naturalist has shown us its purpose, which turns out to be ornamental rather than useful.

Structurally, this air-chamber or wind-bag, as it proves to be, differs, as we have already hinted, from those which have so far been described, inasmuch as these have been formed simply by inflation of the food-pipe or gullet, whilst in the case of the bustard the chamber is an entirely independent structure. Extremely thin-walled, it extends from the base of the tongue down the front of the neck, immediately beneath the skin, to its base. In fully-developed examples this remarkable pouch is found to have a bulb-shaped termination, the which lies between the arms of the merry-thought. Air is admitted through a small hole at the base of the under-side of the tongue, and when the display of the proud performer is finished, the air is expelled again from the same aperture. During the display small quantities of air appear to be expelled for the purpose of producing a sound said to resemble the word "oak," possibly to attract the attention of the lady of his choice, who often affects an absolute indifference or even ignorance of the fantastic performance which is intended for her eyes alone.

Some doubt still exists as to whether this pouch is retained throughout the year, or whether, after the season of courtship, it becomes absorbed to be re-developed in the succeeding spring.

It seems but natural to suppose that the method of courtship displayed by the great bustard would be adopted by the bustard tribe in general. As a matter of fact, however, such is by no means the case. No other bustard has succeeded in attaining such a pitch of artistic display. The nearest approach thereto, perhaps, is that made by the giant Australian bustard, *Eupodotis australis*. But he has not the skill of his British cousin. His attitude at this time is distinctly "wooden." Throwing the tail upward and forward over the back, the neck is then stretched to its greatest length and held stiffly upwards, whilst at the same time great gulps of air are drawn into the gullet till a long pendulous and feather-clad bag is produced which hangs down considerably below the level of the breast. At the throat is a great bulbous swelling which causes the feathers in this region to stand on end, and thereby add to the effectiveness of the whole display. The attitude complete, the ardent swain stands motionless, mutely pleading for the approval of his prospective mate. Here again, be it noted, no special apparatus, no true air-sac or wind-bag has been produced. The same methods have been resorted to which are employed by the frigate-bird and

the pigeon. In the swollen throat we may get an inkling of the origin of the remarkable wind-bag of our British bustard. For it is easy to see that a similar throat-swelling in the ancestors of this bird may have given place to a pocket-like structure which in course of time increased to form what, for the sake of the simile, we may call the stocking-shaped bag of to-day. The gradual increase of the pocket to its present proportions is to be attributed to the fact

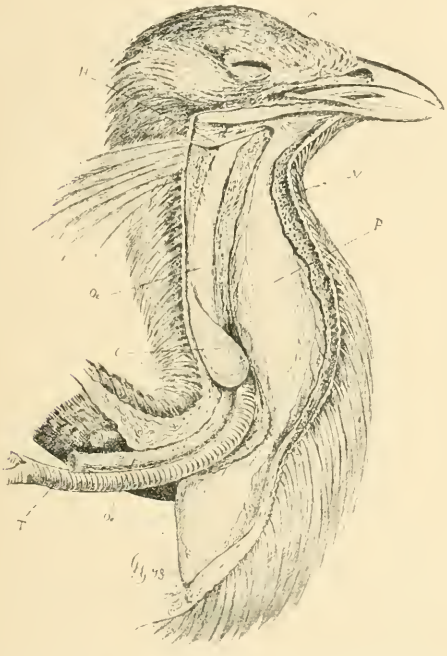

Fig. 2.—Dissection of the right side of the neck of the Great Bustard, *Otis tarda*, to show the hour-glass-shaped gular pouch. Drawn from the specimen in the British Museum. *C*, Crop; *H*, Hyoid; *Oe*, Oesophagus; *P*, Pouch; *T*, Trachea; *V*, Vascular tissue, investing the upper part of the pouch.

that the birds with the largest throat pouch found most favour with the females of the community and were selected on this account as mates. The birds with the largest throat pouches being selected in each succeeding generation, the present race, with its enormous wind-bag, was produced.

The only other bird with a throat pouch filled in the same way as that of the great bustard is the Australian musk-duck (*Biziura lobata*). The males only bear the pouch, which differs conspicuously from that of the bustard in that it is external, hanging down, purse like, from the lower jaw. Nothing, however, appears to be known as to the use to which the pouch is put, but there can be little doubt but that it is a purely sexual character, and displayed as a charm during courtship.

Many lizards possess throat pouches of this kind, but whether they are in all cases used exclusively for the purposes of display we do not know; on this point observation by travellers is silent. In many cases the inflation of the pouch is accompanied by a display of brilliant colour over its surface. For example, in one of the iguanas, *Anolis carolinensis*, of the south-eastern United States, the pouch, when placid, is white with a few lines and spots of red, but at the moment of inflation it becomes suffused with a brilliant vermilion.

The curious but unsightly air-sac of the adjutant stork may well close this series of examples of ornamental wind-bags. Doubtless many of our readers have watched, in the London Zoological Gardens, the ease and rapidity with which this sac can be filled and emptied. Like that of the great bustard it is a specially developed structure, and quite distinct from the gullet. Unlike the pouch of the bustard, however, its general form and proportions, both when inflated and when empty, are visible externally, for it is quite pendulous, and covered only by the bare skin of the neck. Moreover it is present at all seasons. Empty, it looks like a small conical bag projecting from the front of the neck, but when filled, its shape is completely changed since it forms a bladder-like body a foot and a half long. The method of inflation is quite unique, the pouch communicating with a large cavity below the orbit on the left side of the base of the skull, and this opens directly into the nasal cavity.

WHORLS AND CRESTS OF HAIR AS ANIMAL PEDOMETERS.

By Walter Kidd, M.D., F.Z.S.

The works of man which he devises for his physical and mental advancement are marked by a precision varying with the degree of maturity of his science, and one of the smaller among these is the pedometer, an instrument requiring here no description. By a somewhat elastic use of the idea of a pedometer, one may find among the phenomena of nature certain which may be termed *animal pedometers*; these, like all the products of nature's handiwork, are lacking in the exactness of human appliances. But they are none the less significant of certain habits belonging to the animals which possess them.

Comparatively few animals can be said to carry about on their bodies a register of their locomotive activity as a cyclist does on his machine, or a pedestrian in his pocket. Nevertheless, those few mammals that display pedometers on their hairy coats, "*urbe et orbi*," show an advance in one particular upon any of man's pedometers, inasmuch as fairly clear records of ancestral as well as individual activities are indicated. The phenomena here looked upon as animal pedometers are those arrangements of hair which we know as whorls, found in various regions of the bodies of animals, and seldom in any but the short-coated forms. These whorls do not often exist alone, but usually are associated with a feathered arrangement which proceeds against the general stream of hair adjoining them, and this feathering generally terminates somewhat sharply in a ridge or crest. Whorls, featherings, and crests then constitute a fully-formed "pedometer" in this connection. The best examples of these, and the most familiar, are those seen on the horse, and they are so far removed from being accidental or indifferent phenomena, and are so clearly brought under certain simple laws of physical causation, as not only to deserve but to demand interpretation. Few thoughtful persons will dissent from the remark in the conclusion of Jevon's Principles of Science, where he says, "Now among the most unquestionable rules of scientific methods is that first law that *whatever phenomenon is, is*. We must ignore no existence whatever; we may variously interpret or explain its meaning and origin, but if a phenomenon does exist, it demands some

kind of explanation." To these small and apparently unimportant fragments of nature's handiwork, which are here called pedometers for the sake of emphasis, this unexceptionable remark of the great logician applies.

It may be best at the outset to state that, from their intrinsic importance, whorls, featherings and crests are excluded entirely from the province of any form of selection, being in no way useful to the animal possessing them, and in no degree produced by artificial selection or breeding. Their production must be sought elsewhere, and no view of this is forthcoming but that which considers them as by-products of muscular action in a long line of ancestors, and in a very striking way they register the degree and range of this action.

As already stated, the best examples of the phenomena in question, and the greatest number, are to be found on the coat of the domestic horse, and these will first be described. The best known is that graceful feathering which passes upwards in the hollow of the flank, dividing the trunk of the animal from the great rounded mass of muscle of the hind-quarters, and the feathering presents and the hinder one more directly in its original course along the great swelling mass of the hind-quarters. A better idea of the actual arrangements of the hair-streams will be gathered from an inspection of the coat of any common horse, whose coat is not too long, than can be conveyed by a written description. The symmetry and constancy of this arrangement is very striking and demands explanation. This is more fully treated in (1), (2), (3),* and it may be shortly stated that these breaks in the uniform direction of the hairy covering of the horse, and other animals, as well as in other regions of their bodies than the inguinal, are due to the constant traction, during exercise, of underlying and diverging muscles. It is here maintained that they fairly bear the name of pedometers because of the close way in which the degree of locomotive activity is registered according to the persistence, size, and constancy of these otherwise uncalled-for arrangements of hair. When a few horses in the act of trotting are watched, and the accompanying diagram of the main muscles of the horse and the commonest whorls, featherings and crests are borne in mind, it is seen at once that the

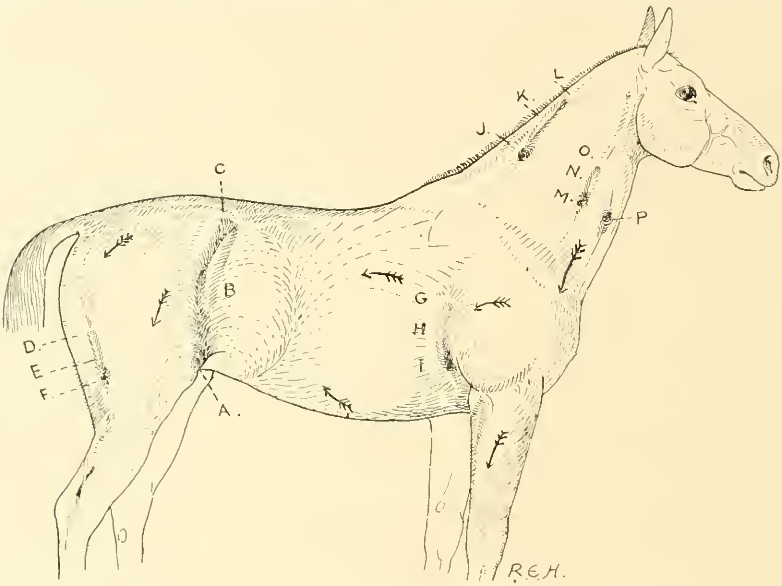

FIG. 1.—Side View of Horse: A, B, C, Inguinal Whorl, Feathering, and Crest; D, E, F, Gluteal Whorl, Feathering, and Crest (very rare); I, H, G, Axillary or Post-humeral Whorl, Feathering, and Crest; J, K, L, Upper Cervical Whorl, Feathering, and Crest; M, N, O, Middle Cervical Whorl, Feathering, and Crest; P, Lower Cervical Whorl.

a direction slightly concave forward. It commences at the fold of skin, which passes from the lower part of the abdomen to the hind-limb, by a whorl or vortex of hair. This radiates and expands into a bilateral and symmetrical expansion shaped like the barbs of a feather. The latter proceeds upwards in the inguinal hollow as far as the level of the iliac crest, where a projection covered by muscles is always to be recognised, and here it abruptly terminates in a ridge or crest. The crest is very noticeable in all domestic horses, and lies parallel with the long axis of the trunk. Above it, and on either side of it, are seen the hair-streams from the back of the animal, breaking away like two currents of water on either side of an outstanding rock, the anterior stream passing with a wide curve forwards and downwards along the side of the abdomen, very conditions required to produce some departure from the ordinary slope of the hairs in the inguinal hollow are present, if indeed it be a possibility that underlying divergent muscular traction should influence the course of the living growing stream of hair on that portion of the skin which lies over the area affected. If also a few horses be watched as to the degree and extent of the "jolt" which occurs at every quick step, and the sharp limitation of this to the area included in that of the whorl, feathering and crest—ceasing, as it does, abruptly and significantly at the level of the crest of the ileum—the *modus operandi* is very clear. The forward range of the

* (1) *Proc. Zool. Soc. Lond.*, 1900, p. 682. (2) "Use-inheritance": A. & C. Black, London, 1901. (3) *Proc. Zool. Soc. Lond.*, 1902, p. 156.

"jolt" is much wider than the backward, and marks out most closely the degree of the forward curve taken by the anterior hair-stream, which descends from the crest. In passing, one may note here a very small and unimportant point, but one which is of some interest. During or after a short shower of rain the flank of a horse presents a curious distribution of the moisture. At a point just where the proper forward stream from the feathering joins the main stream of hair from the thorax and abdomen, a definite line of darker moist hair is seen, and the moist surface is confined closely to the anterior part of the trunk, and separated from that of the hollow of the flank. This line of demarcation very clearly indicates the position where the forward "jolt" in rapid action terminates.

For the production of these and kindred peculiarities in other animals no other than this dynamical explanation is forthcoming, and no other seems to be required. The arrangements of hair described is the best, because the most familiar, of the pedometers displayed by animals on their bodies.

Attention to the facts of the horse's life and certain related or contrasted facts of the lives of other animals will show the reasons for which such hair-arrangements are looked upon as registers of long-past and present activities of the species in question The domestic horse is the most locomotive of animals, wild or domesticated. It has been produced by man out of a wild plastic stock, with some such ancestors as the wild (Prejevalsky's) horses now at the Zoological Society's Gardens, and by a process of selection during many generations, first in its Central Asian cradle, and later all over the civilised world. It has been as much made by man for his purposes of locomotion, draught and traffic, as a locomotive engine has been made by him. The one has been made by the laws of applied physics, and the other by those of biology. Thus the domestic horse is in the unique position of being the locomotive animal *par excellence*, and that not for its own needs, but for those of higher creatures who have availed themselves of its potentialities provided by nature. These considerations show the domestic horse to be the best specimen which can be found for the study of animal pedometers, and by comparison of this species with all other known hairy mammals it is found to be as much better furnished with pedometers of the kind indicated as it is greatly in advance of them as to the frequency and rate of its locomotive activity.

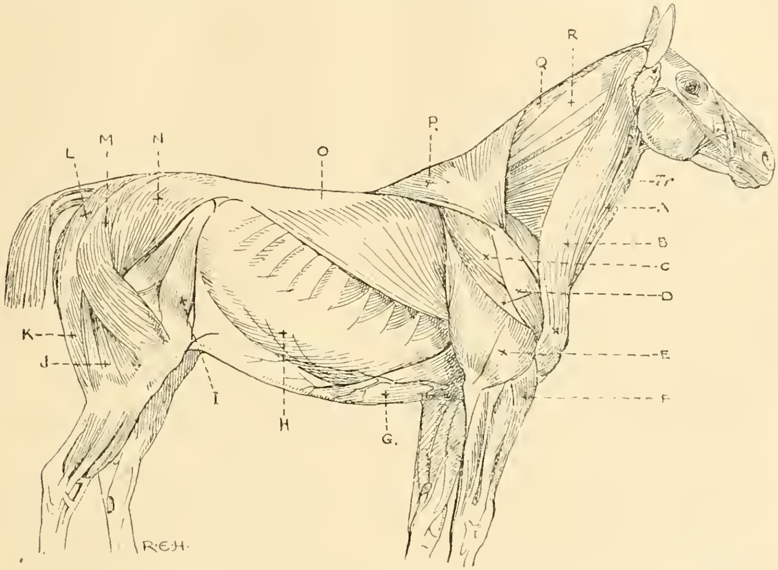

FIG. 2.—Side View of Horse showing chief Superficial Muscles.

There are two closely related animals, the domestic ass and mule, which ought to show this inguinal pedometer, if mere heredity or some variation incidental to the group of animals could be fairly invoked to account for it. These also are locomotive animals, but in a degree very much less than the horse, and their pace is of a quieter and less free character. What then do we find in them as to the size and persistence of the inguinal pedometer? In the ass it is absent (the writer has met with one exception), and in the mule it is variable and occupies less than half the area of that in the horse. These facts agree very closely with the hybrid character of the mule and with the differing locomotive activities of horse, mule and ass. Prejevalsky's horses show a whorl and feathering of an oval shape and limited size, very much like that of the mule. The onager (*Equus onager*), closely resembling these three domestic animals in form, shows an inguinal whorl or pedometer large and well defined, though much less so than in the case of the horse, which is in keeping with its character for remarkable fleetness and activity. Zebras of the three forms, Mountain, Grevy's and Burchell's zebras, show no whorl here at all, in spite of their close resemblance in size and form and *power* of locomotion to the horse. Their wild lives, lived only for their own sake and not for that of man, have been only locomotive in the intermittent way which is incidental to all wild life.

The domestic ox, and most of the Bovidæ, show no

inguinal whorl, and in the case of the former we can explain, from our knowledge of its slowly-moving action and general heaviness, this negative fact.

Among the Bovidæ certain antelopes, gazelles, and sheep exhibit a more or less defined inguinal pedometer, and these are given in more detail elsewhere.*

The special instance of an animal pedometer, which has been described at some length, will serve to illustrate others less well known, and among these, as one would expect, the greater numbers are found in the domestic horse.

Behind the large mass of the muscles of the shoulder, and in a hollow corresponding to the inguinal hollow, there is found just below the withers of some horses a whorl which may be counted among the pedometers of that useful creature. Being not a constant phenomenon it is the more significant from one point of view, for it is evidently a pedometer in process of evolution at the present time. It is never so highly developed or so large as the inguinal, and out of 2159 horses examined it was found to exist in only 42 cases, or about 2 per cent. In another group of 87 cases in which it existed there were 57 cart-horses, and this singular fact is readily accounted for when one recollects that this hollow is a region where a decidedly less extended range of action occurs than is the case in the inguinal, except in the particular instance of the cart-horse, where it is markedly greater than in any other form. It is sufficient to watch a fine English cart-horse drawing a heavy weight, and to compare with this action even that of the high-stepping hackney, to see at once why the preponderating muscular activity of the cart-horse in this area is stamped upon its hairy covering as a whorl, or pedometer. Here again is the degree of locomotive activity registered by the frequency and size of a whorl and its associated phenomena. This particular post-humeral pedometer is also found in other Ungulates, and the most noticeable specimens are found in the same group of animals as the inguinal whorl, and these are given in detail in the same place.*

On the pectoral region of certain animals, among which the Ungulates in general and the horse in particular may be mentioned, there is a bilateral symmetrical whorl with feathering and crest, as a rule, associated. Here, again, is a pedometer which registers the general activity of the species and its ancestors, and the individual range and frequency of movement of the great muscles which flex the "elbow" of the animal. In our familiar show-specimen, the horse, it is invariably present and fully developed, varying only to a slight degree in size in differently developed individuals of this convenient species.

In many wild animals it is present, as in many Bovidæ and a few of the larger Carnivores, but never with the uniformity and degree of development that occurs in the horse. Once more the ass and mule deserve special notice as to the degree in which the pectoral pedometer is displayed by them. In the mule it is small, narrow, nearly always present, in the ass it is very rarely present; indeed, as mentioned above, the present writer has only examined one specimen in which it occurred. The horse has been stated to show the pectoral pedometer invariably, but the importance of this fact does not end with its constancy, for many degrees of its width and length are to be observed, and it is a rule to which no exceptions have been so far found, that the general development of it is in a direct ratio with the action of the horse in question. In cart-horses, powerful carriage horses, and funeral horses it is highly developed, and in shambling ill-bred hackneys, such as one sees in the streets of Italian cities, it is very

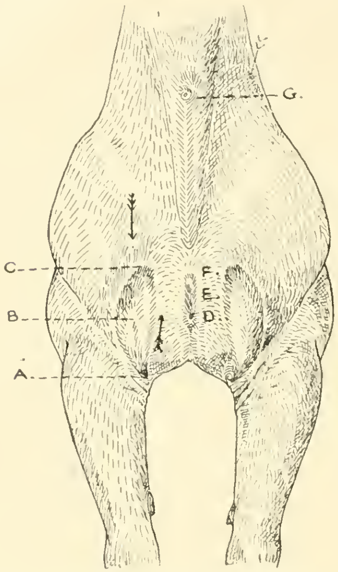

FIG. 3.—Front View of Horse's Chest, showing the Whorls, Featherings, and Crests.

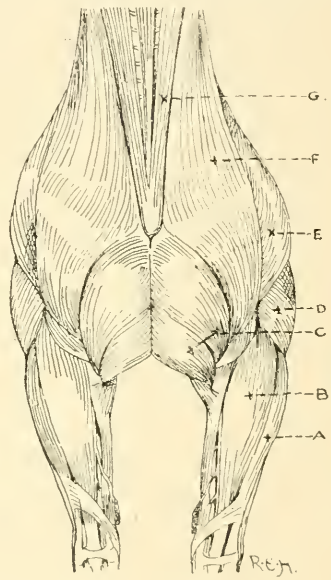

FIG. 4.—Front View of Superficial Muscles of Horse's Chest.

* *Proc. Zool. Soc. Lond.*, 1900, p. 686.

* *Proc. Zool. Soc. Lond.*, 1902, p. 686.

narrow and ill-developed. Some of these poor specimens, if examined as they approach, as to their pectoral pedometer alone, would be taken for mules, which resemble them most closely in this particular, and indeed in general build as well. It is not necessary to do more than point out the close correspondence of the relative locomotive activities of the horse, ass, and mule with the degree of development of the pectoral, as was seen in the case of the inguinal pedometer.

In point of importance, from the present aspect of them, the pedometers in the inguinal, pectoral, and post-humeral regions may be numbered 1, 2, 3.

There are several other situations of the animal body where whorls, featherings, and crests occur, but these three that have been mentioned are the only ones that can be described as pedometers, the others being either due to pressure or being secondary to general muscular activity, as in the sides of the neck, but not being by-products of *locomotive* activity *per se*. The horse, again, is pre-eminent in these other whorls, inasmuch as it presents no fewer than three invariably, and nine frequently.

A few facts concerning these particular whorls, featherings, and crests may be alluded to in conclusion :—

1.—They occur in a direct ratio with general muscular development in an animal, and the difference between the size and definition of the whorl of an animal which is large and fat, but not muscular in proportion, and an animal which shows good muscular development, is very significant.

2.—They never occur over the middle of one large muscle, and only where groups of muscles underlying the part exercise traction in opposing directions.

3.—They never occur in Carnivores ; though here it may be said *exceptio probat regulam*, for two out of the vast number of Carnivores examined, viz., two long-bodied domestic dogs of the dachshund type, with very strong fore-quarters, showed a rudimentary post-humeral whorl.

It may prevent misconception to state here that the term "pedometer" is used loosely, and chiefly by way of illustration, but that it is faithful to the facts, which are of a simple order, and open to the study of all whom they may concern.

THE SUN'S DUSKY VEIL.

By Miss Agnes M. Clerke.

None of the solar appurtenances is more obvious to inspection than the screen of attenuated matter overspreading the photosphere. Already, in 1612, Lucas Valerius recognised the darkening of the sun's limb which results from its action. Bouguer, more than a century later, measured the gradations of darkening; Laplace calculated, from the basis of Bouguer's measures, the total amount of light-stoppage in the so-called atmosphere ; and Father Secchi perceived the stoppage to be selective, the surviving marginal rays showing a rufous hue. Moreover, since these are very imperfectly actinic, photographs of the sun exhibit the edges of the disc as much more obscure than they appear to the eye. The solar and terrestrial atmospheres are then so far alike that both are heavily absorptive of blue light, while transmitting red and yellow beams with comparative freedom. Yet it does not follow that the sun resembles the earth in being surrounded by an envelope of refrigerated gases. This is indeed impossible under the given conditions. Let us briefly recall their nature.

The sun's tinted screen must be situated in the immediate neighbourhood of the photosphere.* Faculæ visibly overtop it ; their upper sections escape the dimming effects of its intervention. They seem like half-submerged stakes in a tideway, that serve, not only to mark the channel, but to show the depth of the water. Now faculæ themselves can be readily located. They are clearly photospheric protuberances. This relationship attests itself indeed to the eye, yet still more convincingly by spectroscopic evidence. Facular light is impressed with the whole array of Fraunhofer lines. It escapes none of the absorption exercised by the vaporous layers near the sun. It has then demonstrably been sifted through them. Faculæ, then, rise from the photosphere, surmount the screening envelope, and are immersed in the reversing stratum. A vaporous layer, however, lying between the reversing stratum and the photosphere, should necessarily be incandescent ; and incandescent gases stop only special luminous vibrations ; they are incapable of producing a general absorption, such as shadows the solar limb. Hence the interposing veil can only be of a pulverulent composition ; cool vapours, placed in the torrid situation where it exists, should, in a few minutes, become glowing ; and the action of glowing vapours would be indistinguishable from that of the reversing layers.

But whatever its constitution, there can be no doubt as to the importance of its function in the solar economy. Stripped of its "atmosphere," the sun would appear fully one stellar magnitude brighter than it actually does. The change might be described as equivalent to the rise of Aldebaran to the rank of Arcturus. Further, its thermal power would be nearly doubled.† As one result of the subsisting arrangement, then, the solar expenditure of energy is strongly controlled. The resources of the great globe are husbanded, and its vital span must be proportionately lengthened. Hence the solar stage of development may be inferred, on this ground alone, to be one of relative permanence. For white stars, radiating from bare photospheres, waste their stock of power recklessly ; while the provision of a "niggard" apparatus in later life prolongs existence by economising the means of sustenance.

Dr. J. Halm is perhaps the first investigator adequately to appreciate the significance of that darkening of the sun's limb which is so easy to observe, so difficult to account for. "One would have thought," he writes‡, "that such an important fact as this quite enormous light-and-heat-absorbing faculty of the solar atmosphere would have led solar physicists to enquire whether, in view of the stupendous changes going on incessantly at the sun's surface, we can possibly rely on the absolute constancy of the solar envelope, or whether the density of the absorbing matter might not rather be exposed to variations which would lead to serious consequences as regards the maintenance of the thermal equilibrium in the solar body. So far as we know, however, such an attempt has never been made."

But the author has evidently overlooked the enquiry started in 1890 by Mr. Wilson, of Daramona, and Dr. Rambaut, the present Radcliffe observer, as to the real occurrence of just the variations in question.§ They laid down the plan of observations designed to extend

* Dr. Scheiner, it is true, places it in the chromosphere ("Strahlung and Temperatur der Sonne," p. 50), but gives no satisfactory reason for the transference.

† Professor Frost found, from an elaborate series of experiments, that the sun's output of heat would be augmented 1·7 times by the removal of its absorbing envelope (*Astronomy and Astrophysics*, Vol. XI., p. 731).

‡ *Annals of the Royal Observatory, Edinburgh*, Vol. I., p. 74.

§ *Proc. Royal Irish Academy*, May 9th, 1892.

throughout an entire solar cycle, but only some preliminary sets were executed, and the project was left in abeyance. The subject has been quite lately—since the appearance of Dr. Halm's discussion—resumed by Prof. Very in America.* By means of spectro-bolometric measures at various points on the sun's disc, he proposes to ascertain whether the curve of diminishing radiant energy from centre to limb remains constant, or alters in form from time to time or progressively; and this, as Mr. Wilson and Dr. Rambaut had pointed out, would serve to test the occurrence of changes in the quality or depth of the solar atmosphere. The quantities concerned would in any case, Prof. Very remarks, be of a very small order; still, he regards their discrimination as possible by an extension of the method practically exemplified in his paper, the determinations being made predominantly at epochs of spot-maxima and minima. Only at a great public observatory, he adds, could the grasp and continuity needed to give substantial value to the work be secured.

Meanwhile no proof—no suspicion even of a proof—is as yet at hand of fluctuations in the effectiveness of solar heat-conservation. That it has a secular tendency to augment is, however, rendered probable by the fact that stars, on the whole, redden with antiquity, and upon this slow process interruptions may possibly supervene. The question remains open. The affirmative answer to it supplied by Dr. Halm is based upon theoretical considerations. He assumes that the sun is a cooling body, and hence that the absorption due to its waste products is, on the whole, in course of intensification. Nevertheless, vicissitudes have to be reckoned with, and their consequences are supposed to occasion and prescribe all the complex phenomena connected with the periodicity of the sun. For intensifying absorption brings in its train an excess of heat-retention. The protective envelope becomes over-protective. It more than redresses the balance between thermal loss and gravitational restoration. Superheating sets in, eruptions ensue, and the atmosphere is temporarily cleared. Then the swing of change begins anew. The eleven-year cycle is in fact established.

There is much in this speculation that allures thought. It is novel, it is reasonable, it smoothes away some outstanding difficulties, it affords a prospect of escape from the weary round of abortive hypotheses. It seems, above all, comprehensive enough to include the problem of light-variability in red stars. Yet, when we come to details, the way out appears, after all, to be hopelessly blocked. Like many other solar theories, this new and highly ingenious one promises more than it can perform. Its merits are undeniable; but it does not meet the full exigencies of the situation.

The cyclonic hypothesis of spot-formation does duty once more in Dr. Halm's solar scheme. Eruptions take the initiative; their subsiding materials diffuse into polar and equatorial currents; and the encounters of those oppositely directed, and issuing naturally from different sources of disturbance, produce vortices showing to the eye as spots. But these are affected by no such conspicuous and systematic internal movements as should appear in them if they in truth originated after the supposed fashion. Spots fitfully gyrating do indeed occur, but they attract attention as rarities. No more than two or three per cent. of the whole thus distinguish themselves. And even in these the movements are capricious and unmethodical. Opposite rotations are sometimes perceived to proceed simultaneously in different members of a single spot-group; nay, one of the aggregated umbræ may wheel by turns in contrary directions. Effects so casual cannot depend upon a fundamental cause; and they indeed necessarily arise when matter drawn towards a centre deviates, however slightly, from a radial course. Dr. Halm tries to reconcile the contradiction between what his theory demands and what observation attests by suggesting that the gyrating portions of a spot are mainly those that are invisible; but the plea is inadmissible. A genuinely spiral structure should throughout bear the imprint of certain characteristic features. The "thatched edges," for instance, which so often constitute penumbræ, could no more subsist as the garniture of a whirling umbra than the ship of Ulysses could have escaped engulfment by Charybdis. Nor are the umbral cavities uniformly dark. Secchi frequently saw them overspread with a sort of flocular haze; Mr. Maw has noted in them delicate, vein-like traceries; and the "black holes" first detected by Dawes are unmistakably chasms of irregular shapes and stationary behaviour, not foci of swirling movements. The claims to acceptance of the cyclonic theory of sunspots are in fact less plausible now than they seemed thirty years ago, when less evidence had been accumulated by which to try their validity.

This, fatal though it be, is not the only objection to Dr. Halm's views. They are also in glaring disaccord with observation as regards the connection of spots with prominences. They involve the production of spots, certainly as a consequence, but far from the neighbourhood of a primary outburst of metallic flames; while for the avowed object of harmonising this state of things with what is actually seen, a further expedient is resorted to.

If a spot be a vortex, there must be an indraught of the surrounding atmosphere towards its centre. The screening action accordingly, owing to which heat collects and finally occasions eruptions, should be particularly effective over a maculated region. Hence, it is alleged, the close association of prominences with spots. But what are the facts? Far from being obscured by extra-absorption, spot-bearing tracts of the photosphere are usually of dazzling brilliancy. And for this precise reason that they are often measurably *humped up* as if by the relief of pressure, thus partially discarding the veil uniformly spread over the unbroken disc. The escape of heat pent up by an atmospheric cloak has then assuredly nothing to do with the genesis of prominences.

There are indeed many more reasons than can be here adverted to in detail for rejecting the opinion that spots are mere eddies in the drifting luminous material of the photosphere. Thus Mr. Maunder has expressly dwelt, in the pages of this journal, upon peculiarities in their movements and mode of development indicating their deep-seated nature.* And the strange frequency of antipodal outbreaks, both photospheric and chromospheric, intimate as their precedent conditions, disturbances reaching to the very core of the globe.

Dr. Halm's interpretation of solar phenomena cannot, it is clear, be accepted in its entirety; yet it includes much that is instructive and suggestive. Especially noteworthy is the relation elicited by him from Spoerer's and Carrington's observations, between the rate of solar rotation and the condition of the solar surface. When spots are numerous, he finds reason to conclude that the equatorial drift is quicker by 750 miles a day than when spots are scarce. The figures tabulated certainly show a cyclical variation of the indicated kind; and the result is in itself plausible. It needs, however, to be verified, since figures are apt to show illusory coincidences which vanish with the repetition of the series. But the enigma of the sun's rotation has hitherto proved so baffling that any hint towards its solution is welcome; and should

* *Astrophysical Journal*, Vol. XVI., p. 73.

* KNOWLEDGE, Vol. XVII., p. 200.

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COMET *b* 1902 (Fig. 1).

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COMET *b* 1902 (Fig. 2).

its angular speed be proved actually to fluctuate synchronously with the eleven-year wave of solar commotion, an important step will have been made towards unravelling its intricacies.

The whole subject of solar physics is, year by year, taking a wider scope, and acquiring a deeper significance. The complexities of the lighting and warming apparatus of our system, its self-regulating power, the manifold interplay of its parts, the fine poise of its equilibrium, strike us with increasing wonder as we become more intimately acquainted with them. More and more keenly, too, we feel our ignorance as we advance in knowledge; information on many points is, indeed, still in a visibly rudimentary state, but it is gradually gaining further items, and while ambitious theories are constructed only to collapse, something of value survives from the wreck of each—a crucial circumstance previously overlooked, an original train of reasoning, a valid analogy. The gate of mystery, it is true, remains closed, notwithstanding the many "Open Sesames" that have been uttered in front of it. Yet it hangs more loosely on its hinges than of old, and science has fresh engines in reserve.

PHOTOGRAPHS OF COMET *b* 1902 (PERRINE).

By Isaac Roberts, d.sc., f.r.s.

Six photographs of the comet have been taken at my observatory with the 20-inch reflector, and five with the 5-inch Cooke lens simultaneously, between September 6th and October 10th, 1902, and the two photographs on the plate annexed illustrate the appearance and show the position of the comet on the days herein given.

Fig. 1.—The comet is shown as it appeared on the 6th September, with an exposure of the plate during ninety minutes; the plate being held, by aid of the clock mechanism, steadily on one point in the sky whilst the comet moved in its course, leaving a trail on the film which represents the distance it travelled in its orbit during the exposure of 90 minutes. On examination of the trail on the negative, by aid of a lens, it is seen to be formed of a series of circular dots which closely resemble the images of rather faint stars that are visible on the plate around the comet; but inasmuch as the comet was travelling in its orbit at the rate of about 1·15 seconds of arc each minute of time during the 90 minutes' exposure of the plate, and only eight dots are visible in the trail, it follows that a very short interval of time was required to form each dot.

How were the dots formed? There was no movement of the plate during the exposure that would account for them, and the comet, we must assume, kept steadily on its course along its orbit without jerking or stopping. The answer to the question is, doubtless, that during the exposure of the plate the transparency of the atmosphere varied frequently, and the clear intervals, though of very short duration, sufficed to give the highly actinic nucleus time to leave its image on the film, but when less clear intervals occurred, the nuclear image varied in intensity down to invisibility. These facts indicate that the nucleus was of globular form; that it was highly actinic, for although surrounded by a dense *coma* of nebulous matter, it did not obstruct the light of the nucleus so as to prevent its image being formed on the film in a few minutes of time. The nuclear images are round notwithstanding the rapid movement of the comet in its orbit. The diameter of the nucleus measured about 14 seconds of arc, and the length of the trail about 103 seconds.

Fig. 2.—The photograph was taken on the 10th October, with an exposure of the plate during 52 minutes in the 20-inch reflector, and it will be observed that the star images upon it consist of a series of zigzag trails, whilst the nucleus of the comet is round. In this case the nucleus was used as a fixed point for guiding purposes, whilst the images of the stars are trails which represent the distance in space over which the comet moved during the exposure of 52 minutes. The trails were produced by the frequent necessity of moving the photographic plate, in order to counteract the motion of the comet, and keep it, as steadily as possible, upon the crosswires in the eye-piece of the guiding telescope during the whole exposure; the number of the zigzags in the trails register the number of the corrections made during the exposure of 52 minutes.

The comet appears, on this photograph, as if it had been viewed at rest in a telescope, and the various details in its structure are therefore seen with but little distortion.

I do not consider it necessary for me to write any descriptive matter here; each reader can see for himself, by examination of the photographs, the *coma*, the tail divided with rifts, and the separation into two tails. One of them is about two degrees in length, and the other about one degree. Of course some of the fainter details can only be well seen on the original negatives, six of which are available for examination in the event of any scientific investigations requiring their use.

THE LUNAR ECLIPSE OF 1902, OCTOBER 16.*

A series of measures was made by Prof. W. H. Pickering of the diameter of the bright spot surrounding Linné before and after the passage of the shadow of the earth during the total lunar eclipse of October 16, 1902. The measures were all made in a north and south direction, with the filar micrometer attached to the 15-inch equatorial. The magnifying power used was 550 diameters. The seeing was fairly good, and nearly uniform throughout the observations, being about 5 on the standard scale of 10 (*Harvard Annals, XXXII.*, 120). After the passage of the shadow, it was slightly inferior, perhaps 4. Unfortunately clouds stopped observations before an absolute measure of the quality of the seeing could be made. Various corrections were made to the measures for the thickness of the micrometer thread, the pitch of the micrometer screw, and for a subjective effect described in *Harvard Annals, XXXII*, page 204. During the observations on October 16 the sun had been shining on Linné from 8·5 to 8·7 days.

On October 16, on the approach of the umbra, and when the penumbra already lay across Linné, the white spot began to grow in size, and by the time that the umbra had passed away, its diameter was very materially increased by an amount of 2″·75. This increase was notably larger than that caused by the eclipse of 1898, when Mr. A. E. Douglas estimated by three different methods the increase to be 0″·82, 0″·73, and 0″·15; or than that of 1899, when Mr. W. H. Pickering estimated the increase to be 0″·14. Mr. Pickering remarks that in the present instance the great increase in size could not have been due to defective seeing after totality, for the effect of bad seeing on spots of this size is rather to diminish their dimensions, as shown by the measurements of artificial disks, and therefore could not produce the effect observed. "Moreover," he says, "this change in size was so conspicuous to the eye, even before I made any measures, that at first I queried whether the object could really be Linné. To satisfy myself I re-identified it by means of some small craterlets in its immediate vicinity. It is certain that at no time during the observations was the

* Harvard College Observatory Circular, No. 67.

seeing as good nor as bad as it had been during some of the observations made in 1898 and 1899, when the spot was very much smaller.

"The real explanation of the unusually large change in the size of the spot," he continues, "I believe to be that Linné was more active than heretofore, and therefore that there was more moisture about it to condense.

"A series of measures made on October 20, at 15h. 26m., or $12^{d}\cdot 6$ after sunrise, gave a diameter of $4''\cdot 61$; seeing 3 in the standard scale. The seeing, as judged by the image of the moon, was clearly inferior to that at any time during the night of October 16. The image of Linné was much larger than it appeared by any of the measures made before the eclipse, and much smaller than it appeared by any of the measures made after it. It therefore appears that the sudden increase of size after totality could not be due to inferior seeing.

"It also appears that on or before October 20 the spot had again begun to shrink in size, due, presumably, to evaporation in the intense sunlight. Four measures of the spot made in 1898, from $12^{d}\cdot 4$ to $13^{d}\cdot 7$ after sunrise, gave diameters of $3''\cdot 52$, $3''\cdot 24$, $3''\cdot 42$, and $3''\cdot 46$ (*Harvard Annals*, *XXXII.*, 206). The measures made on October 20, 1902, $4''\cdot 61$, therefore confirms those of October 15 and 16, in showing that the spot has increased in size during the last three years."

Letters.

[The Editors do not hold themselves responsible for the opinions or statements of correspondents.]

THE VISIBILITY OF THE CRESCENT OF VENUS.

TO THE EDITORS OF KNOWLEDGE.

Sirs,—In the December issue of Knowledge is a letter on the visibility of the crescent of Venus with the unaided eye, with regard to which I should like to make a remark.

At the time of the observation—the end of October or beginning of November, 1901—Mercury would, of course, be a beautiful crescent.

The writer of the letter points out the planet to two naked-eye observers, and then they are shown the crescent in the telescope. Their attention is *then* directed to a similar object in proximity to that just examined. Now, under the circumstances, perhaps it is not altogether surprising that one of them should have the sagacity (shall I call it) to infer that the "shape" would be "just like the new moon."

But the second part of the observation, referring to the "rest of the star, the dark round we see," is beyond my comprehension, and I should like to ask the writer if he can kindly describe its appearance in the telescope. I suppose it had some reference to earthshine upon our satellite.

T. H. Astbury.

Croft Villas, Wallingford.

HABITS OF SANITATION.

TO THE EDITORS OF KNOWLEDGE.

Sirs,—I have read with much interest the article by Mr. Cox on the "Domestic Economy of the Thrush." As regards the sanitary habits of the thrush and other birds, may I suggest that the practice is much more common than appears to be known, and was probably originally followed by all animals whose young are helpless and incapable of locomotion. The domestic cat disposes of the excreta of her young in the same way, and for the first three weeks her nest is absolutely sweet and clean.

M. S. S.

NOTES.

Astronomical.—Fizeau's experiment for the determination of the velocity of light has recently been repeated on an imposing scale by M. Perrotin, Director of the Nice Observatory. The mean result of 1109 observations gives the velocity in vacuo as 299,860 kilometres or 186,328 miles per second. Taking the value $8''\cdot 805$ for the solar parallax, as derived from observations of Eros, the theoretical value of the constant of aberration is $20''\cdot 465$, which, it is gratifying to find, is exactly that adopted by the International Conference of 1896.—A. F.

New Comet (1902 *d*).—A new comet was discovered on December 2, and, though extremely faint at present, it occupies a very favourable position for observation. Early in December it was estimated as about magnitude $11\frac{1}{2}$. On January 1, 1903, the comet will be placed about nine degrees west of the bright star Procyon, and a week later may be found some eight degrees west of β Canis Minoris. At this period the comet will be nearly three times as bright as it was on the night of its discovery. Its motion is slow towards the north-west, and directed to the stars in the western region of Gemini. The comet is well visible during nearly the whole night, and promises to remain in view for a considerable period, for according to the elements of the orbit computed by Ebell at Kiel (*Ast. Nach.*, 3834), the perihelion passage will not take place until April 19 next.—W. F. D.

Botanical.—It is probable, judging from the enquiries occasionally made, that the interesting articles published on the Mexican jumping bean are not generally known. The beans (or seeds) are not infrequently met with, being distributed as curiosities remarkable in possessing the power of motion. The cause of this motion was not difficult to explain, for on cutting through the seeds, a single whitish worm was found in each. This was the larva of an insect to which the name of *Carpocapsa saltitans* was given many years ago, but it was not till 1891 that Dr. Rose, of the United States National Herbarium, was able to identify the plant which produced the seeds, though it was known that it belonged to the Spurge family (Euphorbiaceæ). From the observations made by Dr. Palmer while collecting plants in Mexico, and from the specimens which were received from him, it was concluded that the source of the jumping beans was a new species of *Sebastiania*, which Dr. Rose called *S. Palmeri*. This is a diœcious shrub or small tree, with the usual three-celled capsule of the order. Each cell contains a subglobose seed about two lines in diameter. The larva is supposed to be hatched from an egg deposited on the outside of the capsule, which it penetrates while still very young. It remains for a long period in the larva stage, during which it feeds on the substance within the integuments of the seed, nothing remaining but a thin light shell, which on being detached readily responds to the peculiar movements of the larva within. Usually the seeds are moved from side to side, but sometimes they are made to jump short distances. The jumping bean insect is closely related to the common apple worm (*Carpocapsa pomonella*). It is known to attack the seeds of a second species of *Sebastiania* (*S. Pringlei*), while an allied species

is found in the seeds of *S. bilocularis*. In referring to the jumping bean, the late Prof. Riley called attention to the extraordinary seed-like galls found in great numbers on the leaves of some North American oaks. The ground where they have fallen seems to be alive with motion, and the noise which this causes resembles the pattering of rain. The galls are produced by *Cynips saltatorius*, which, in the pupa state, is said to be capable of jumping twenty times its own length.—S. A. S.

ENTOMOLOGICAL.—A most important contribution on the "Bionomics of South African Insects," with regard to the value of natural selection as explaining cases of "warning coloration" and "mimicry," appears in the latest number of the *Transactions of the Entomological Society of London* (1902, pp. 287–584, Pls. IX.–XXIII.), being the conjoint work of Mr. G. A. K. Marshall and Prof. E. B. Poulton. Numerous experiments on the palatibility, or otherwise, of Acraeine and Danaine butterflies and other insects with "warning colours" are recorded. The general impression given by the records is that "warning colour" is frequently, though by no means always, of protective value. Mantids, for example, appear not to recognise these colours as indicating distastefulness, though they often refused Acraeine butterflies after trial, and when induced to eat them through hunger, suffered in health. Perhaps the most valuable support afforded by Mr. Marshall's observations to the theory of natural selection is his undoubted demonstration that butterflies are frequently pursued by birds and superficially injured by them, thus effectually disposing of the objection that butterflies have nothing to fear from birds. The observations on seasonal dimorphism in the genus *Precis* are of very special interest. It seems likely that the striking difference between the dry and wet season phases of these insects is due to the need for perfect protective resemblance in the former season, when insectivorous animals are short of food, and the struggle for survival among insects is very keen, and to the advantages of warning colours in the latter season when insect life is abundant.

During the last ten years M. Chas. Janet has published twenty-two valuable "Etudes sur les Fournin, les Guêpes, et les Abeilles." His latest contribution is a careful study of the structure of the hind-body in the common red ant ("Anatomie du Gaster de la *Myrmica rubra*." Paris: Carré and Naud, 1902). The musculature, the nerve-centres, the digestive system, and the reproductive organs are described in detail, and the functions of the various parts discussed.—G. H. C.

GEOGRAPHICAL.—Dr. Sven Hedin, who read a paper on his last journey in Central Asia, to the Royal Geographical Society on December 8th, seems to lack no quality necessary for a great explorer. His previous journeys, as well as his latest journey of nearly three years' duration, have proved him to be one of the finest travellers the world has seen. Not only is he possessed of remarkable endurance and great pluck and determination, but he has great powers of observation, and understands besides what is important to examine and record minutely, while his knowledge of languages is extraordinary. In the short time available in an evening, Dr. Hedin could describe but a portion of his long and arduous journey, but we believe that a popular account of his expedition will be published shortly, while the scientific results cannot of course be made known until the mass of material and the records obtained have been worked out, and this will be carried out by specialists under the auspices of the Swedish Government. A part, at all events, of these results will be published in the English language. The geographical portion of the scientific results will be provided by the traveller himself, and the material obtained will necessitate the complete revision of existing maps of Eastern Turkestan. The following is an outline of Dr. Hedin's journey:—Leaving Kashgar, in Eastern Turkestan, in September, 1899, Dr. Hedin proceeded eastwards up the Yarkand River, and eventually arrived in the region of Lob Nor. Here he found a ruined town, which he twice visited and partially excavated. Amongst other valuable material, Dr. Hedin found in these ruins a number of Chinese manuscripts which throw light upon the physical and political geography of the interior of Asia during the first centuries after Christ, and show what prodigious changes have taken place in that part of the world during the last fifteen hundred years. These finds and Dr. Hedin's careful investigations of the neighbouring Gobi Desert lead him to the conclusion that Lob Nor, or the Lake of Kara Koshun, is gradually creeping northwards, and will eventually reach the bed in which it certainly was in the year 265 A.D. After the completion of this work in the Gobi Desert and round Lob Nor, Dr. Hedin went into camp for a month and prepared a large caravan for a journey southwards into Tibet. We have not space for a description of Dr. Hedin's two most determined and plucky attempts to reach Lhasa. Each time he was confronted and surrounded by greatly superior forces of armed Tibetans, who had the strictest injunctions not to allow him to proceed. After trying every means in his power to gain entry into the holy city, he was at last forced to turn to the west, and, crossing the northern part of Tibet from east to west (in itself a remarkable journey), he arrived at length in Kashmir in December, 1901. Spending his Christmas at Leh, and the early part of January, 1902, with Lord Curzon, at Calcutta, he then returned to the north, and, picking up his caravan again, proceeded from Leh back to Kashgar, where he arrived on March 14th, 1902.

ZOOLOGICAL.—At the meeting of the Zoological Society, held on November 18th, was read an extract from a letter from Mr. D. Russell, Hon. Sec. to the Otago Acclimatization Society, giving an account of the successful naturalization of the red deer in New Zealand. Two stags and six hinds had been turned out in 1868, and their offspring now numbered between 4000 and 5000 individuals. The carcases of some of these deer weighed from 500 to 600 lbs.

The variation in the shape of the antlers of the Scandinavian elk formed the subject of a communication from Dr. Einar Lönnberg, of Upsala, read at the following meeting of the same body. In this it was shown that elk are not unfrequently met with in Scandinavia with antlers of the general type of those recently described as *Alces bedfordiæ*; these elk also differing somewhat in bodily shape and colour from the ordinary form. Since, however, they do not seem to be restricted to a particular locality, they cannot apparently be regarded as indicating a distinct race. A reindeer skull, with antlers, from Novaia Zembia, was also described at the same meeting, and regarded as belonging to a new race nearly allied to some of the American forms of the species.

Two important memoirs on the fauna of the northern part of the Western Hemisphere have recently appeared. Under the title of "Grönlands Pattedyr," Dr. H. Winge (*Meddelelser om Grönland*, Vol. XXI.) publishes an annotated list of the land and marine mammals of Greenland. In the course of his notes he mentions that the reindeer skulls and antlers recently described by Signor Camerano as *Rangifer spitzbergensis*, are really from Greenland. The second of the two memoirs, by Mr. E. A. Preble, forming No. 22 of the *North American Fauna*, is devoted to the mammals

and birds of the Hudson Bay district. Although comparatively few forms are described as new, the notes in this memoir are very important to naturalists, since, judged by modern standards, our knowledge of the Hudson Bay fauna was very imperfect.

ROYAL SOCIETY'S MEDALS.—The medals of the Royal Society have been awarded this year as follows:—

The *Copley Medal* to Lord Lister, in recognition of the value of his physiological and pathological researches in regard to their influence on the modern practice of surgery. The main result of those researches, namely, the definite proof that the suppuration of wounds, no less than putrefaction, was the work of living organisms, was not reached as a happy accident; it was the natural outcome of long-continued scientific observation and reasoning.

The *Rumford Medal*, which is awarded for "new inventions and contrivances by which the generation and preservation and management of heat and of light may be facilitated," was given to the Hon. Charles Algernon Parsons. By his invention and perfection of the steam turbine, he has not only provided a prime mover of exceptional efficiency working at a high speed without vibration, but has taken a step forward which marks an epoch in the history of the application of steam to industry, and which is, probably, the greatest since the time of Watt

The *Royal Medals* were conferred upon Prof. Horace Lamb, for his investigations in mathematical physics, and Prof. Edward Albert Schäfer, for his researches into the functions and minute structure of the central nervous system, especially with regard to the motor and sensory functions of the cortex of the brain.

The *Davy Medal* was given to Prof. Svante August Arrhenius, for his application of the theory of dissociation to the explanation of chemical change.

The *Darwin Medal* was awarded to Mr. Francis Galton, for his numerous contributions to the exact study of heredity and variation contained in "Hereditary Genius," "Natural Inheritance," and other writings. It may safely be declared that no one living has contributed more definitely to the progress of evolutionary study, whether by actual discovery or by the fruitful direction of thought, than Mr. Galton.

The *Buchanan Medal*, awarded every five years for distinguished services to hygienic science or practice, is given to Dr. Sydney A. Monckton Copeman, for his experimental investigations into the bacteriology and comparative pathology of vaccination.

The *Hughes Medal* has been conferred upon Prof. Joseph John Thomson, in recognition of his contributions to the advancement of electrical science, especially in connection with the phenomena of electric discharge through rarefied gases.

British Ornithological Notes.

Conducted by HARRY F. WITHERBY, F.Z.S., M.B.O.U.

Swallows' Nesting Habits.—Mr. Cox, in his interesting article on the "Domestic Economy of the Thrush" (KNOWLEDGE, December, 1902), says that the parent birds seem to feed the young ones indiscriminately. The following will show that this is not the case with all birds. One morning a pair of Swallows flew through the dressing-room window into my brother's bedroom at Frocester Court, Gloucestershire, perched on a picture, chattered, and, apparently, took stock of the place. This they repeated for several days, and, finally, made a nest in the bedroom about on a level with one's head. During incubation the chambermaid might come into the room, and do her ordinary work, but if she went near the nest the bird flew out of the window. *If a stranger or any other member of the household* entered the room she flew out at once. On the other hand, she allowed my brother to do anything, take her off the nest and put her back, handle the eggs, and so on. When the young were hatched he noticed that the cock fed, say, No. 1 and then No. 3, the hen feeding Nos. 2 and 4; so he tried to puzzle them by repeatedly shifting the young ones; but the birds always knew which had been fed last, and never made a mistake. In course of time they flew, but always returned at night till, early one morning, the whole family, instead of flying out for the day as usual, perched on the rail at the head of the bed and kept up an incessant twittering for an hour or more, and then flew off not to return that year. I may mention that my brother had placed a chain and padlock on the window to prevent anyone closing it. A pair tried to repeat the process next year, but for obvious reasons were not allowed to do so, and the window was kept closed till, I suppose, they had selected a nesting place elsewhere.—GEORGE J. CHAPMAN, Carlecotes, Dunford Bridge, Sheffield.

Migration of Blue-headed Wagtails (Motacilla flava) in Kent and Sussex.—Mr. N. F. Ticehurst has lately been keeping observation, with Mr. M. J. Nicoll, on the migration of Wagtails along the coast of Kent and Sussex. The conclusion reached is that the Blue-headed Wagtail, which has been considered hitherto as an irregular visitor on migration to Great Britain, is a regular visitor over this whole area. It arrives from the 20th of April to the 1st of May, and it is thought that some remain to breed. The return flight of these birds consists chiefly of young ones, which pass about the third week in August.

Water Pipit (Anthus spipoletta) in Sussex.—At the November meeting of the British Ornithologists' Club, Mr. Howard Saunders exhibited a female specimen of a Water Pipit obtained by Mr. M. J. Nicoll in Rye Harbour on October 29th. This bird seemed to be the seventh example of the species recorded for Sussex, while a specimen had been procured in Carnarvonshire and another in Lincolnshire. The Water Pipit is very much like the Scandinavian form of the Rock Pipit. It seldom visits us, although it breeds as near to us as in the Alps and the mountains of Germany and Central Europe, as well as in the Pyrenees and some of the mountain ranges in the Spanish Peninsula.

Glossy Ibis in Ireland (The Field, November 29th, 1902, p. 930.)—The Glossy Ibis has been recorded from England several times this autumn, and now Messrs. Williams, of Dublin, record that a male specimen was shot in Co. Clare and a female near Wexford.

All contributions to the column, either in the way of notes or photographs, should be forwarded to HARRY F. WITHERBY, *at the Office of* KNOWLEDGE, 326, *High Holborn, London.*

Notices of Books.

"HISTORY OF ASTRONOMY DURING THE NINETEENTH CENTURY." Fourth edition. By Miss Agnes Clerke. A. & C. Black. 1902.) Illustrated. 15s.—In a few words Miss Clerke gives a picture of the state of sidereal science when the last quarter of the eighteenth century began. "It included," she says, "three items of information: That the stars have motions, real or apparent; that they are immeasurably remote; and that a few shine with a periodically variable light. Nor were these scantily-collected facts ordered into any promise of further development. They lay at once isolated and confused before the inquirer. They needed to be both multiplied and marshalled, and it seemed as if centuries of patient toil must elapse before any reliable conclusions could be derived from them. The sidereal world was thus the recognised domain of far-reaching speculations, which remained wholly uncramped by systematic research until Herschel entered upon his career as an observer of the heavens."

And now we have entered on the first quarter of the twentieth century, and the intervening years have been as many centuries in the multiplication of facts and fancies in this same sidereal science. All the greater need that they should be marshalled and passed in review; that fact should be joined to fact in a promise of further development; that proved fact should be disjoined from unproven fancy lest the two together should point out a wrong conclusion, and knowledge be darkened in a confusion of words. This gigantic task Miss Clerke first undertook in 1885, in her first edition of this book. A second edition followed, and a third in 1893. The nine years which followed witnessed such a march in almost all the branches of astronomy that in her fourth and present edition Miss Clerke has found it necessary to rewrite the book almost from cover to cover. That the volume does not bulk larger than the previous editions is due to the smaller print and thin paper which the publishers have used.

Miss Clerke's qualifications for her task are unique. The first requisite—patient industry—has been pre-eminently hers. The thoroughness with which she worked over the ground covered by the astronomers of the earlier part of last century, and the persistency with which she has kept her finger on the pulse of the science, from the time when she first commenced the work, are most remarkable. But the "History" is far indeed removed from any mere dry-as-dust compilation, for with rare judgment she orders fact and theory in their due proportions, pointing out their accordances, discrepancies, and contradictions; the accordances which establish the truth of a theory; the contradictions between fact and theory that cry out for the reconstruction of the latter; the discrepancies which so often point out the openings to new avenues of knowledge. But great research and rare judgment may be, and indeed often are found together in a book that is almost unreadable, through the writer's powerlessness of expression. But not here, for Miss Clerke's literary skill and brilliant style are even more apparent than her industry and judgment. It may be possible to find here an important observation overlooked, or there a wrong conclusion, but throughout the whole volume it would be impossible to find a dull page or an ambiguous sentence.

Where the whole is so excellent it may seem somewhat ungracious to call attention to what is perhaps little more than some dust on the balance, but Miss Clerke herself has led the way for its removal by reversing many of the conclusions recorded in the earlier editions.

One of these conclusions still finding place in the fourth edition is the too close connection claimed for Carrington's and Hodgson's "white patches" of solar light on September 1, and the magnetic disturbances of the same day. It is true that a great magnetic storm raged from August 28 to September 4, but at the actual time of Carrington's observation there was a lull in this storm, and, as Mr. Ellis pointed out in *Nature* for 1893, the magnetic trace was but disturbed by a small "twitch" of such a common and ordinary character, that we cannot believe that it was any direct result of the solar outburst. Such "twitches" have been noted since at all periods of sunspot activity, but Carrington's observation has never been repeated.

In another case Miss Clerke fails to see the force of her own reasoning with respect to the constitution of the planet Venus. In one place she says:—"We are almost equally sure that Venus, as that the earth is encompassed with an atmosphere." In another, when discussing spectroscopic observations of the planet: "Some additions there indeed seem to be in the thickening of a few water and oxygen lines; but so nearly evanescent as to induce the persuasion that most of the light we receive from Venus has traversed only the tenuous upper portion of the atmosphere. It is reflected at any rate with comparatively slight diminution." And again: "The reflective power of Venus must be singularly strong. And we find, accordingly, from a comparison of Zöllner's with Müller's results, that its albedo is but little inferior to that of new-fallen snow; in other words, it gives back 77 per cent. of the luminous rays impinging upon it." Now it is evident from these observations that we do not receive light from Venus herself, but only from the outer surface of her atmosphere, and that therefore it is not possible for us to see the configuration of the planet's crust. Miss Clerke acknowledges this, but in the matter of the planet's rotation, she is overpowered by the positive assertions of careful and trustworthy observers that markings seen by them have altered their position; more especially is she influenced by the great names of Schiaparelli and Lowell. Since the publication of the "History," Mr. Lowell has withdrawn his observations of radiating markings on Venus, as evidence showed them to be subjective; and as for other observers, their many discrepancies seem indeed but to strengthen the theoretical position that we do not and cannot see the seas and continents of Venus and their rotation, be it fast or slow round her axis.

"Journal and Proceedings of the Royal Society of New South Wales."—One of the most interesting papers in this volume is by Mr. G. H. Knibbs, F.R.A.S., on "The Principle of Continuity in the Theory of Space." The subject is treated with more lucidity than might have been expected where not only pure but pseudo-homaloidal space of n-dimensions is taken into account. It is obvious, as the author puts it, that if we define a point as of zero-dimension (as Euclid does the continuous generation of a finite quantity by a finite number of additions is not a conceptual possibility. We cannot agree with him, however, that it is any less obviously inconceivable that such a quantity can be continuously generated by an infinite number of point additions. Where the zero is absolute, and not merely a quantity which is infinitely small, the summation of an infinite number of such zeros cannot result in the generation of a finite quantity, even though the infinity were of a very large order.

"Our Country's Fishes and How to Know Them." By W. J. Gordon. (Simpkin.) Coloured plate. 6s.—This little book, compiled from various sources, is intended to be used as a key by those who may desire to identify the adult forms of any of our British fishes. The style of composition leaves much to be desired, to say nothing of accuracy. Thus we are informed that "the flat-fish start as very thin youngsters swimming the ordinary way up . . . . and their eyes in the normal places, one on each side of the head: but apparently, failing to thrive under these conditions, they betake themselves to the ground where . . . . their head turns over so as to bring both eyes on the top. . . ."! Again we read, "Some are said not to know a sole from a lemon sole: the only way out of the difficulty is to know what a sole is like, the lemon sole being what may be called various, and generally but a somewhat distant relative"! Minor inaccuracies are of course inevitable, they will creep in despite the greatest care; on these then we will be silent.

BOOKS RECEIVED.

Practical Photo-Micrography. By Andrew Pringle, F.R.M.S., &c. (Iliffe.) Illustrated. 3s. 6d. net.

Man. II. 1902. (Anthropological Institute.) Illustrated. 12s. net.

First Stage Botany. (Organized Science Series.) By Alfred J. Ewart, D.SC., PH.D., F.L.S. (Clive.) Illustrated. 2s.

Atlas of Popular Astronomy. By Thomas Heath, B.A. (W. & A. K. Johnston.) Illustrated. 7s. 6d.

Electrical Installations. By Rankin Kennedy, C.E. Vol. III. (Caxton Publishing Co.) Illustrated.

Qualitative Analysis. By L. M. Dennis and Theodore Whittelsey. (Ginn & Co.) 4s. 6d.

Light for Students. By Edwin Edser. (Macmillan.) Illustrated. 6s.

Waves and Ripples in Water, Air and Æther. By J. A. Fleming, M.A., D.SC., F.R.S. (S.P.C.K.) Illustrated. 5s.

Year-Book of the Scientific and Learned Societies. (Chas. Griffin.) 7s. 6d.

Text-Book of Palæontology. By Karl A. Von Zittel. Vol. II. (Macmillan.) Illustrated. 10s. net.

Jena Glass and its Scientific and Industrial Applications. By Dr. H. Hovestadt. (Macmillan.) Illustrated. 15s. net.

Celestial Mechanics. By F. R. Moulton, PH.D. (Macmillan.) 14s. net.

Annuaire Astronomique et Météorologique, 1903. By Camille Flammarion. (Paris: Librairie Ernest Flammarion.) 1 fr. 50.

The Master and his Method. By E. Griffith-Jones, B.A. (Hodder & Stoughton.) 1s. net.

The Shroud of Christ. By Paul Vignon, D.SC.(FR.). (Constable.) Illustrated. 12s. 6d. net.

Report on the Total Solar Eclipse of January, 1898. By Kavasji Dadabhai Naegamvala, M.A., F.R.A.S. (Bombay: Government Central Press.) 8s.

Monthly Weather Bureau. (Washington: Weather Bureau.) 20 cts.

First Book of Forestry. By Filibert Roth. (Ginn & Co.) Illustrated. 3s. 6d.

Natural Law in Terrestrial Phenomena. By William Digby, C.I.E. (Hutchinson.) Illustrated. 6s. net.

Man's Position in the Universe. By W. Sedgwick. (George Allen.) 6s. net.

"Daily Mail" Year Book. 1s.

Preparatory Lessons in Chemistry. By Henry W. Hill. (Allman.) 1s. Illustrated.

Bible Records of the Earth's Changes. By Joseph Lewin. (Douglas: *Manx Sun* Office.)

Englishwoman's Year Book, 1903. (A. & C. Black.)

Who's Who, 1903. (A. & C. Black.)

Whitaker's Almanack, 1903. 2s. 6d. net.

Whitaker's Peerage, 1903.

Biological Laboratory Methods. By P. H. Mell, PH.D. (Macmillan.) Illustrated. 6s. 6d. net.

Electrical Problems. By William L. Hooper, PH.D., and Roy T. Wells, M.S. (Ginn & Co.) 6s.

Story of Alchemy and the Beginnings of Chemistry. By M. M. Pattison Muir, M.A. (Newnes.) Illustrated. 1s.

Penrose's Pictorial Annual, 1902-3. (A. W. Penrose & Co.)

Symons's Meteorological Magazine, December, 1902. (Stanford.) 4d.

THE NOBODIES, A SEA-FARING FAMILY.

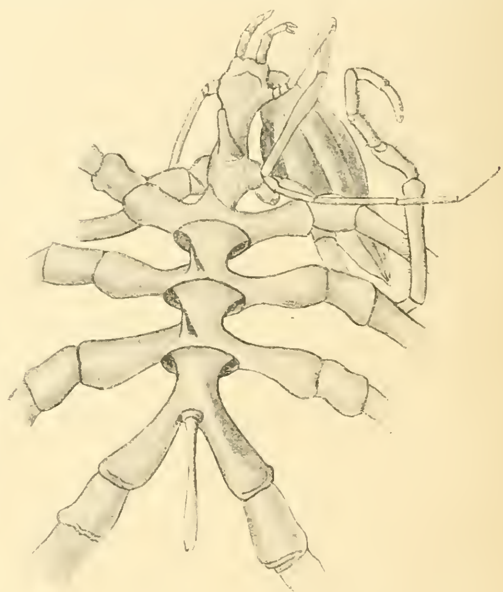
By the Rev. T. R. R. STEBBING, M.A., F.R.S., V.P.L.S., F.Z.S.

CHAPTER V.

A MAN is said to pocket an affront when he demurely lets it pass as though it had not been offered. The "chela-concealing" Cryptochelata have no pocket-like cavities within which to hide their nippers. They either let them vanish altogether, or retain them like superannuated dimples as an ineffective reminiscence of infancy. In classification, however, these disestablished or disendowed chelifori are still useful. They serve to discriminate three families of this section. In the Ammotheidæ they are small, rudimentary, and, in contradiction to their title, not cheliferous. They are small also in the Eurycydidæ, but there imperfectly chelate. In the Colossendeidæ they are entirely wanting. It will not be forgotten that these distinctions apply to the adults, the appendages in question being, so far as is known, present and chelate in the young of all the Pycnogonida.

In the first of the three families above mentioned there are several genera, exactly how many it is not easy to say, because some that are imposing in name are very obscure in nature. Thus *Oiceobathes*, Hesse, "with its home in the abyss," is perhaps the same as *Ammothea*, of which two species have their home on our own shores and shallows. *Pephredo hirsuta*, described by Goodsir, from the German Ocean, is thought by Hoek to be generically the same as *Phanodemus* which Costa instituted earlier for species from the Bay of Naples. *Clotenia*, Dohrn, and *Discoarachne*, Hoek, are, in the opinion of Dr. Hoek himself, closely approximate. They were published in the same year, 1881. Both authors date their work in the same month, Hoek on May 19th, at Leiden, Dohrn on May 31st at Naples. But although Dr. Hoek's "Challenger" report, as he subsequently explained, was ready to appear at the beginning of July, it was not actually issued till October, whereas Dr. Dohrn's Neapolitan monograph was at the service of the public in the preceding September. But the dates are perhaps not the only consideration. In *Clotenia* we find the chelifori dwarfed each to a little stump or tubercle. In *Discoarachne* not even so much as this is either mentioned or figured, so that the name must not be cancelled as a synonym without demur. The disappearance of these little vestigial stumps would probably make no difference to the animal. Nature would view it with unconcern. But the neat simplicity with which our three families have been discriminated will be very much disfigured by it, for the total absence of the chelifori is used as a mark of the third family, not of the first. To put the matter, then, on a broader footing, some supplementary characters of the Ammotheidæ may be given. They have the second appendages from four- to nine-jointed, the ovigerous legs seven- to ten-jointed without claws, and the ambulatory legs provided with auxiliary claws on the back of each principal claw or unguis. Of the genera not hitherto mentioned, *Paribœa*, Philippi, 1843, is obscure. So is *Platychelus*, Costa, 1861, which has, moreover, a preoccupied name. *Tanystylum*, Miers, 1875, takes its title from its tail, which is described as "a long styliform process." *Lecythorhynchus*, Böhm, 1879, is so called from its "flask-shaped proboscis," while *Oorhynchus*, Hoek, 1881, has the "proboscis egg-shaped." In the latter year another new genus united the names of the last two authors, being called *Böhmia* by Hoek in honour of Böhm. Whether *Trygæus*, Dohrn, 1881, is named "full of lees" from the wine-coloured intestinal canal is a riddle which its author leaves for the ingenious to solve. Dr. Dohrn, in 1884, regarded Ammothea, Phanodemus, Pephredo, Pasithoe, Endeis, Pariboea, Platychelus, Alcinous, Achelia, as nothing but names of a single genus. It has been already explained that the last is, in fact, the adult form of the first, but the rest are still indeterminate, and of the species assigned to them it is not certain that all belong to the same family.

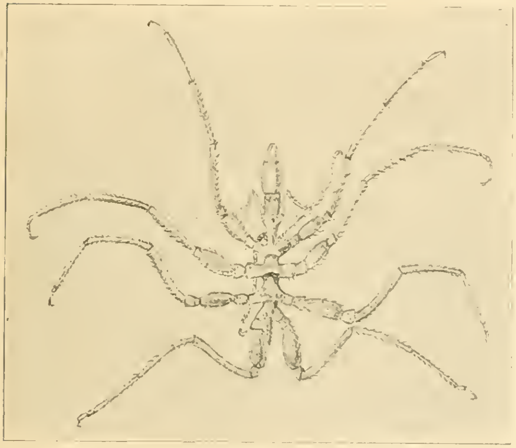
In place of Kröyer's *Zetes*, which was preoccupied, Schiödte introduced the name *Eurycyde*. The first half of this means "broad," and is applicable to the type or premier species of the genus, since the side processes of its trunk-segments are unusually produced, and therefore give a considerable total breadth to the body. But *cyde* is not Greek for a "side," and in the less impossible sense of "glory," the application remains a glorious uncertainty. Be the full meaning of the name what it will, this is the titular genus of the family Eurycydidæ. With the chelifori as already described, this family combines ten-jointed second and eleven-jointed third appendages, the terminal joint of the third being a claw. Auxiliary claws



Ascorhynchus glaber, Hoek. From Hoek.

are not found on the ambulatory legs. The proboscis has the remarkable habit of folding under the body. This peculiarity has been further illustrated in earlier chapters (pp. 75, 138 [1902]). It is also alluded to in the name of *Gnamptorhynchus*, instituted by Böhm in 1879, as the genus of "the bent beak," for a species from Japan. Hoek proposes to make this a synonym of *Ascorhynchus*, Sars, 1876, a doubtful proceeding, since the species described by Sars has the claw of the walking-legs elongate, while the Japanese species is unique in having no claw at all in the first pair of these limbs. Nevertheless, it must be remembered that in two species of

Ascorhynchus which Hoek describes, the claw on these first legs is either very small or "extremely minute." For introducing these confusing links and gradations into our genera we do not pretend to praise nature. We are only describing it. But there is another perplexing circumstance. In the *Ascorhynchus abyssi* of Sars, and the nearly related if not identical *A. tridens* of Meinert, the unconscionable female, instead of having the egg-cells in the fourth joint of the walking-legs, where by rule they ought to be, has them in the second joint. Now here the three species described by Hoek leave us in the lurch, for of two of them only the males are known, and the third, which he calls *Ascorhynchus orthorhynchus*, ought perhaps to be transferred to a new genus, since the solitary female



Ascorhynchus tridens, Meinert. From Meinert.

specimen from New Guinea will not bend its proud proboscis like the other species, and, on the other hand, it has the fourth joint swollen in accord with custom. In this family Sars is disposed to believe that *Alcinous*, Costa, *Parazetes*, Slater, and *Nymphopsis*,* Schimkewitsch, should also be comprehended. *Scævorhynchus*, Wilson, is identified with Ascorhynchus by Hoek.

The remaining family is in some respects the most eccentric and remarkable of all. The members of it, as already explained, have in the adult no chelifori, our last pycnogonid family being so far in agreement, in rather unfortunate agreement, with the families that were placed first forming the section Achelata. But unlike the latter they are fully provided with second and third appendages. This family has been called Pasithoidæ by Sars, on the ground that *Pasithoe*, Goodsir, 1842, though imperfectly known, yet "from the perfect absence of chelifori and the well-developed palpi" must be included in it. But Goodsir's *Pasithoe* may not impossibly be an *Ammothea*, as Dohrn supposed, with the small chelifori overlooked. In 1844, Goodsir mentions a thin narrow projection arising from the anterior edge of the first segment immediately before the ocular tubercle, and continued beyond the middle of the rostrum. That his original account of *Pasithoe* needed revision is thereby made clear, and the narrow projection may refer to the chelifori indistinctly

* An Australian genus, *Nymphopsis*, was founded by Haswell in 1885 (*Proc. Linn. Soc. N.S. Wales*, Vol. IX., pt. 4).

perceived. At both dates he plainly declares that the palpi, or second appendages in his genus are eight-jointed. But Sars defines the family as having the palpi ten-jointed. The genus *Endeis*, Philippi, 1843, has two

Pasithoe vesiculosa, Goodsir. From Goodsir.

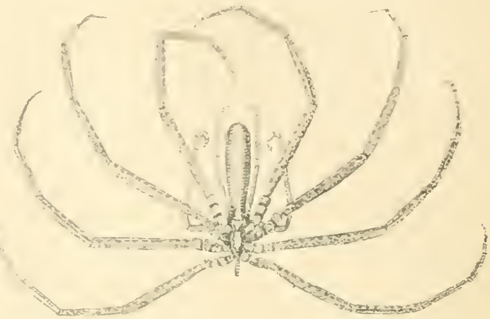
species, but their family affinities also are distractingly vague. In common with Goodsir's *Pasithoe vesiculosa* they are still awaiting re-discovery and re-description. That happy events of this kind are not beyond the reach of scientific expectation derives some warrant from the strange case of *Rhynchothorax mediterraneus*, O. G. Costa, 1861. The Italian zoologist endowed this little creature with one feature so unexampled in the tribe that among the best judges of probability it was frankly disbelieved. He attributed to it a seven-jointed tail-piece. Even the two-jointed tail which the accurate Kröyer described in *Eurycyde hispida* was illusory, the appearance of an articulation depending only on a transverse series of dorsal setæ. At all events the specimens which Dr. Dohrn identifies with Costa's *Rhynchothorax* have the abdomen or tail simple, as it is in all other well-established Pycnogonida. The first of these specimens which Dohrn had the good luck to obtain from dredging at Naples he had the ill luck to lose before he had examined it with care. Every naturalist will sympathise with the pangs of regret he must have suffered, till at a later period other specimens from the same locality came to his relief. Dr. Hoek says: "On comparing the figures of Costa with those of Dohrn, one scarcely knows which is the more striking, the differences or the resemblance; nevertheless Dohrn has identified his species with Costa's, allowing himself to be guided above all by the general impression, and therein, I believe, he has been well advised." In the later and more trustworthy description, no less than in the earlier, there are some highly peculiar features. The front part of the proboscis is imperfectly developed. The ocular eminence stretches forward in a thin process over and beyond the centre of the proboscis. The second appendages are eight-jointed, with anchylosis of the first and second, of the fourth and fifth, and of the sixth and seventh joints. The walking legs have no cement glands in the fourth joint, which is their usual position, but only in the third joint of a single pair, the last but one. The cœcal prolongations of the intestine carry their gland-cells no further than the first, or at most the third joint of the legs, the continuation beyond this being limited to an empty membrane. The ovaries are peculiar by want of peculiarity, eccentric by being commonplace. For, whereas it is the badge of all their tribe to develop ova at least in some joint of the ambulatory limbs, this species is so faithless to the traditions of its race as to have ovaries not extending beyond the lateral processes of the trunk segments. The genital openings are limited to the last pair of legs as in *Pycnogonum*. We may either agree, then, with Dr. Dohrn that Rhynchothorax is the most remarkable of all the Pycnogonida, or we may leave it to

dispute the palm of singularity with Pycnogonum, since the latter has dispensed with a heart and second appendages which the former retains. Both these genera

Rhynchothorax mediterraneus, Costa. From below, legs omitted From Dohrn.

are included by Dohrn in the same family. Sars transfers Rhynchothorax to his Pasithoidæ, without commenting on the diminished number of joints in its second appendages, or on the various eccentricities which seem to demand for it a separate family, Rhynchothoracidæ.

There is still to be considered a genus which, if not the most abnormal, is from some points of view the most extraordinary of all the group. This is the genus of the giant proboscis. It agrees with the Eurycydidæ in having ten-jointed second, and eleven-jointed third appendages, but differs from them in the total absence of chelifori, and in not having its snout flexibly connected with the trunk. The first species of it made known to science was obtained within the Arctic Circle during Parry's first voyage of discovery. The specimen was "found at ebb tide on the shores of the North Georgian Islands." This was described by Sabine in 1821 under the name *Phoxichilus proboscideus*. It was subsequently transferred to a new genus, *Colossendeis*, by Jarzynsky in 1870, and before this name had obtained currency it successively received two others, *Rhopalorhynchus** from Wood-Mason, and *Anomorhynchus* from Miers, the former implying that the proboscis is as massive as a club, and the latter that it is what Dominie Sampson would have called "prodigious." The length of the adult *Rhynchothorax mediterraneus* is a millimetre and a half, about a sixteenth of an inch. Of *Colossendeis proboscidea* (Sabine) the original description says: "proboscis more than twice the length of the body, being one inch eight-tenths, and the body three-quarters of an inch long." The length of the legs is given by Sabine as six inches, which would



Colossendeis proboscidea (Sabine). Reduced. From Sars.

therefore afford a total span of more than twelve. Sars claims for the animal only a length of two inches with a span of nine. But *C. gigas*, Hoek, from great depths in the Southern Ocean, far surpasses either of these sets of measurements, since the animal can attain a length of over three inches with a span of more than twenty-four. To display this creature life-size with its ambulatory limbs unfolded and not overlapping, would require a double-page plate of this magazine. The species of the genus are numerous, and as they have generally been obtained from considerable or very great depths, one may surmise that there is some correlation between their length of limb and the character of their abode. Where the sense of sight has but scanty chances of employment, an extended organ of touch may be very useful, and this will help to explain the parallel case of deep-sea crustaceans, in some of which the antennæ seem ambitious of emulating telegraph wires. Nevertheless, as it happens, it is the short-limbed *C. brevipes*, Hoek, that is recorded from the deepest station of all, 2650 fathoms. The torrid temperature of more than 70° Centigrade, assigned to this abyss in Dr. Hoek's "Challenger" report, is due to a slight confusion. As may be seen from the "Narrative of the Cruise," though the surface water at this station was moderately warm, 70·8° Fahrenheit, the water at the bottom was only a little above freezing point, 32·7° F. Besides its colossal blunt proboscis, *Colossendeis* has various other notable characters. Meinert has remarked the retention of the chelifori by the young of *C. angusta*, Sars, when these juveniles were already more than half-an-inch long. Hoek has drawn attention to the circumstance that the ovigerous legs have not been found carrying ova in either sex. These limbs attain a great length, and shew no sexual difference. In the ambulatory limbs the terminal joint is not here unguiform but awl-shaped, that is, more of a needle than a hook. For what appear to be just reasons, Pasithoe, Endeis, Rhynchothorax have been dismissed from any close alliance with this genus. The family, therefore, in which it stands alone, must take from it the title Colossendeidæ already accepted by various authors.

That there is anything like finality in the classification here adopted, with a few modifications, from Prof. Sars, is not to be expected. All that can be safely assumed is that this is at least as good as any of the several systems hitherto offered, and in the existing state of knowledge the

* This, however, is upheld as distinct by G. H. Carpenter.

most convenient of them all. There is in Scotland a celebrated seat inviting wayfarers to "rest and be thankful." In its high and exposed situation this is sometimes surrounded by a guard of Highland cattle, which by their sturdy attitude seem planted on purpose to discourage indolence. In our pursuit of the Pycnogonida, readers may well think that by this time we must certainly have reached a point if not for gratitude at least for justifiable lassitude. But a final call is to be made on their endurance. The subject itself is in a stage more suggestive of energetic advance than of somnolent repose. In the concluding chapter, therefore, some notes will be offered as to the opportunities which our own country clearly offers for its investigation, and on the literature which is essential for any one anxious to carry forward research instead of re-discovering what is already known.

FAMILIAR BRITISH WILD FLOWERS AND THEIR ALLIES.

By R. Lloyd Praeger, B.A.

I.—THE PEA FAMILY.*

The Order *Leguminosæ* is one of the great plant-groups of the world, myriad in number, ubiquitous in distribution, embracing every kind of plant from tiny herbs to gigantic forest trees, and abounding in useful and hurtful products and properties. As food-producing plants, it is the seeds that are chiefly used. These, enclosed in the *pod* that is so characteristic of this Order, and each containing a good store of food-material for the use of the young plant, are familiar to us as peas, beans, lentils, and haricots. As fodder for domestic animals, the whole plant is valuable in the case of the Clovers, Vetches, Lucerne, Sainfoin, and some of the Lupines. Among drugs, senna is prepared from the leaves of several tropical and sub-tropical species of *Cassia;* and liquorice from the root of *Glycyrrhiza*, cultivated largely in South Europe. Several important gums (gum tragacanth, gum arabic, &c.) are prepared from the juice of species belonging to this Order; other species yield well-known dyes, of which the most important is indigo, prepared from the leaves of tropical species of *Indigofera*. Nor must we omit the numerous species which, both in our fields and our gardens, are conspicuous for their beauty—the Gorse and Broom, Laburnum and Wistaria, the various Acacias and Genistas, the brilliant Clianthus, the Lupines and Coronillas.

This great Order is divided into three sub-orders—the *Papilionaceæ*, *Cæsalpinieæ*, and *Mimoseæ*, and to the first of these, the *Papilionaceæ*, characterized by their peculiarly formed irregular flowers—the familiar Pea-flower—belong all our British species. We have in these countries some seventy-two native representatives of the group, and various others, mostly indigenous in the adjoining parts of Europe, have been introduced accidentally or deliberately by man, and have now made themselves at home among the native forms. None of our plants are arboreal, but the Broom, Gorse, and Genistas furnish a group of shrubs dear to every lover of English landscape. The Vetches and Vetchlings form a coterie of exquisitely graceful and highly interesting climbing plants; while the Clovers, Medicks, Bird's-foots, and their allies constitute an important part of the dense low vegetation of our meadows, banks, and wastes. Among our British *Leguminosæ* are found a remarkably interesting series of morphological and physiological characteristics of varied significance, and pertaining to almost all the different parts of the plant. These must now be briefly reviewed.

First, as to the roots. The roots of Peas, Beans, Medicks, Clovers, and others are remarkable for being the seat of a highly interesting symbiotic union—a living together of two organisms for their mutual advantage; a kind of mutual partial parasitism. If the roots of any of these plants be examined, they will be found to be knotted with small tubercles. The function of these curious structures has previously been briefly referred to in Knowledge (October, 1900) by Mr. H. H. W. Pearson. It is found that these root-swellings are the home of colonies of bacterial organisms. These lowly plants are extremely minute in size and simple in structure, consisting of rows of cells. They increase by the production of spores, or by the simple dividing of the parent. Bacteria possess an important power not possessed by the *Leguminosæ*, though these are so much higher in the scale of life; they can absorb that important constituent of plant-food—nitrogen—directly from the air. By encouraging the growth of these bacteria, then, the plant has at hand a store of nitrogen which it can plunder. The bacteria, on the other hand, live on the sap and cell-contents of the plant which they infest; so both derive an abundant supply of valuable food-material as a result of the partnership. But the existence of bacteria is not necessary for the life of their partners. Peas or Beans grown in a sterilized soil will flourish, but no doubt they have to work the harder for it. Whether the bacteria can, in their turn, maintain permanent independent existence does not appear to be yet known.

From this curious feature of the roots of many of our *Leguminosæ* we pass to a study of their leaves. The reduction in size, or practical suppression, of the leaves of our shrubby species is a remarkable feature. The three native species of *Genista* have, in lieu of the ternate (consisting of three leaflets) or pinnate leaves which characterize the Order, small entire ovate or lanceolate leaves; the well-known Broom has, indeed, ternate leaves, but they appear ridiculously small in comparison with those of other shrubs of similar dimensions—Brambles or Willows, for example. In the Gorse, the reduction of leaf is carried further, and each consists merely of an inconspicuous spine a quarter of an inch long. Studying these plants one will be struck by the green colour of their stems, and thus we discover how they contrive to manufacture sufficient plant-food in the absence of expanses of green leaf; the surface of the stems take up the work usually carried on by leaves. In the Needle Furze (*Genista anglica*), and conspicuously in the Gorse, the reduction of leaf-surface is accompanied by a production of spines. In the Gorse the stems are very much branched, and every branchlet ends in a strong spine, its point wonderfully sharp and hard. This formidable array of bayonets has for its object the protection of the plant against grazing animals, and its efficacy is seen in the way the Gorse grows fearlessly on upland pastures, steadily increasing if not cut down and pushing back the cattle and sheep year by year. That such protection is necessary to the plant is shown by the avidity with which animals will eat it if it is crushed. In some parts of the country such crushing is done regularly as an item of farm economy, as the accompanying photograph, taken in Co. Antrim by my friend Mr. Welch, will show. The plant then furnishes excellent fodder.

In contrast to this comparative unimportance of the leaf, we have in the Vetches and Vetchlings large pinnate leaves which are highly developed, and possessed of a sensitiveness and power of movement that are most remarkable. These Vetches form a group of highly

* For the use of the illustrations which form Figs. 2, 3, 4, and 5, the writer expresses his obligations to Messrs. C. Griffin & Co. They are taken from his "Open-Air Studies in Botany."

specialized climbers. Climbing is a device resorted to by many of our native plants, and by a far larger number in the Tropics, by which, in the keen struggle for light and air, they take advantage of their neighbours to mount on

FIG. 1.—"Knockin' Whins" for Cattle, Co. Antrim.
[R. WELCH, *Photo.*

their shoulders, and thus secure an advantageous position. To assist them in climbing, plants adopt various devices. some merely scramble upwards, maintaining their position by means of wide-spreading leaves or branches; many others use downward-pointing hooks, which anchor them amid the foliage. It is in the twining plants, such as Bryony and Hop, and the tendril-bearers, like the Vetches, that we find the highest development of the climbing habit. These plants live under unusual conditions. In order to gain the light, they must seek, rather than avoid, overhanging foliage; and so we find the Vetches, instead of turning away from the shadow towards the light like most of their neighbours, boldly pushing up into the centre of a bush, to burst into blossom amid its upper branches, far above their less daring neighbours. Again, in these plants, supported by their grasp of adjoining branches, the stem no longer needs to act as a supporting column, bearing the weight of the plant and the stress of weather. It acts rather as a conduit through which water and dissolved salts—the raw plant-food—passes upwards to the leaves. Hence, instead of being thick and stiff, it is thin and flexible; often wonderfully slender when we consider its length, yet strong and supple, to follow without injury the swaying of the supporting plant. But it is in the leaves of these plants that we find the most remarkable modifications adapting them to a climbing habit. The leaves of the Vetches and Vetchlings are pinnate—they bear a number of opposite ovate leaflets. The tip of the leaf-stalk, and the uppermost pair of pinnæ, are in the climbing species changed into tendrils—sensitive, twining, whip-like structures, which exhibit remarkable features. If the slightly curved, extended tendril of a young leaf of Pea or Vetch be watched carefully, it will be found that it is slowly but incessantly moving round and round in a circle. If the tendril comes into contact with a twig, it bends towards it, and eventually takes several turns round it. Even a slight temporary irritation is sufficient to cause a bending towards any side. Finally the tendril becomes woody and strong, and forms a secure anchor-cable for the plant. Not only does the young tendril rotate; the whole leaf on which it is borne is in continual motion. The shoot to which the leaf belongs is rotating also, so that the tendril is sweeping the air with a complicated motion, in the course of which it is almost sure to strike against some stem or twig of the surrounding vegetation. It is interesting to note that a few species of these climbing genera are low-growing, make no attempt to climb, and that in these, tendrils are not developed. Such are the Wood Bitter Vetch (*Vicia Orobus*), which grows in bushy clumps, and the tiny Spring Vetch (*V. lathyroides*), whose home is on short sandy turf. Also the well-known Tuberous Bitter Vetch (*Lathyrus macrorrhizus*), and the Black Bitter Vetch (*L. niger*). In all these the stem terminates neither in a tendril nor in a leaflet, but in a short point. Two other native species of *Lathyrus* possess peculiar leaf-modifications which are worthy of study. In the Grass-leaved Vetchling (*L. Nissolia*) no leaflets are produced, and instead the leaf-stem which usually bears them is expanded into a narrow flat leaf, which so nearly resembles those of the grasses among which it grows that it is almost impossible to detect the plant when it is not in flower. The seed-pods also are long, narrow, and green, and only the solitary rose-red blossoms betray the presence of the plant. The Yellow Vetchling (*L. Aphaca*) has gone to another extreme. Its leaf is wholly converted into a long undivided tendril. To act as a substitute in the important work of assimilation, the stipules, which in the Vetchlings usually take the form of a pair of small leaf-like organs clasping the stem at the base of each leaf-stalk, are here enlarged, and form a pair of large triangular pseudo-leaves at each node. From the axil of the tendril-leaf springs the flower-stalk, bearing a single yellow blossom. To convince ourselves of this curious shifting of responsibility we have only to examine seedlings of the plant. We then find that just as the seedling Gorse shows true trifoliate leaves giving way to spines, so in this species the first leaf has a pair of leaflets, and is accompanied by a pair of stipules of the normal size and shape.

FIG. 2.—Leaf of Bush Vetch, *Vicia sepium.* Half natural size.

FIG. 3.—One Node of Yellow Vetchling (*Lathyrus Aphaca.*) Half natural size.

The familiar peculiarly shaped flower of, for instance, the Sweet-Pea, Broom, or Laburnum, is most characteristic of the sub-Order *Papilionaceæ*, to which belong all our British *Leguminosæ.* This flower is profoundly modified to suit the visits of insects, which effect cross-fertilization. The axis of the flower, as in most of the more highly specialized entomophilous flowers, is horizontal. The calyx is more or less cup-shaped, with five teeth of varying length, and it is persistent throughout the period of flowering and fruiting. The corolla consists of five petals. The upper one (the *standard*) is large and broad, often variegated with stripes of a second colour, and forms a kind of roof. Two narrower ones (the *wings*) are placed below, one on each side; and more or less enclosed by them, the fourth and fifth are slightly joined together along their lower margin, and form the *keel.* Ten stamens spring, like the

petals, from the base of the calyx-tube; their filaments are usually united in the lower portion into a tube, which surrounds the ovary; their free ends curve upwards, fitting the upward curve of the keel, along the bottom of which they lie. The ovary is one-celled, capped by the long style, which follows the curve of the stamens. The blossoms generally possess a brilliant colour—yellow and red being the prevailing tints among our British species—and an attractive odour. These flowers are essentially constructed to be fertilized by bees. The brilliant upcurved standard renders the flower conspicuous. The horizontal position of the flower fixes the manner of approach. The "wings" guide the insect in entering the flower to seek the honey, which lies on the inner side of the bases of the filaments. The mechanism for dusting the bee with pollen varies in different species. In the Clovers and others the weight of the bee causes the stamens and stigma to slide forward out of the keel, the stamens depositing pollen on the underside of the bee's body, while the stigma takes up pollen that may be adhering there in consequence of previous visits to other flowers. In the Genistas, Medicks, and Broom, the keel more tightly confines the stamens and pistil, which rupture the keel with explosive force on pressure produced by a bee's visit, dusting the insect with pollen. In Rest-harrow, Lady's-fingers, &c., there is a kind of piston mechanism, the stigma sliding forward and pushing out against the bee's body a small quantity of the pollen, which is shed by the stamens, and collects in the forward end of the keel. Finally, in Vetches, Vetchlings, &c., the style bears a brush of hairs, which similarly sweeps the pollen out of the keel against the body of a visiting bee. In the Broom, half the stamens are shorter than the others. When a bee alights on the flower, first the short stamens explode out of the keel, dusting the underside of the insect; then the long stamens spring out, and shed their pollen on the bee's back.

When the flower is fertilized, the ovary grows, and develops into the *pod*, which is so characteristic and well-known. In some genera, such as the Clovers, the petals do not fall, but remain, brown and dry, covering the short fruit; but in the more conspicuous cases the pod is long and bare. These pods have in many cases a peculiar method of sudden rupture, and consequent scattering of the seeds which they contain. When the seed is ripe, as the pod dries, certain strong-walled cells which run diagonally across each valve of the pod contract spirally, causing a torsion which eventually ruptures the pod with violence, each valve twisting spirally, and flinging the seeds to a distance. The burst pods of *Lotus corniculatus* will be found to have each valve twisted by several convolutions; and on a hot summer's day, amid a grove of Gorse the air is sometimes filled with the cracking of the pods as they explode. The seeds contained in these explosive pods are often comparatively heavy, the embryo being set between two ample pads of food-material; nevertheless,

FIG. 4.—Fruit of Reticulated Medick, *Medicago reticulata.* × 3.

they are ejected to a considerable distance, and the seedlings grow up clear of the parent plant. A different mode of dispersal is adopted by many of the Medicks. The pod is curiously modified, being curled up in a close spiral, and furnished with numerous conspicuous curved spines. The spines cause the pods to become attached to passing animals—probably to their feet, for the plants grow low on the ground—and thus they become widely dispersed.

Finally, we may briefly pass, in review, the various British members of this interesting and beautiful Order of plants. Of the shrubby species, we have the Broom (*Cytisus scoparius*), the only British representative of a well-known Old World genus. Of Gorse there are three closely allied species (*Ulex europæus, U. nanus, U. Gallii*). The first occurs throughout our Islands, the second chiefly in the south of England, the third mostly in the west and in Ireland. Of the three Genistas (*G. tinctoria, G. anglica*, and *G. pilosa*), the first two range through England into Scotland, the third being a local southern English plant; all are absent from Ireland. Of Rest-Harrow (*Ononis*), there are likewise three species, of which two are wide-spread, the third, *O. reclinata*, being a small southern annual. The little Fenugreek (*Trigonella purpurascens*) is an anomalous plant that has had a temporary home in many genera; it is very local in distribution. The native Medicks are six in number, and show a great variation in their pods, which may be bare and nearly straight, or curled into a close ball and densely spiny. They are plants of dry places and waste ground, and have their head-quarters in south-eastern England, like most genera of similar proclivities. Of the pretty Melilots, only one species, *M. officinalis*, is reckoned native, but several others have colonized our country, or appear as ballast plants The Trefoils (*Trifolium*) are the largest British genus of the Order, numbering eighteen native species, and half-a-dozen others more or less thoroughly established. Some of these, such as the well-known Red Clover (*T. pratense*) and Dutch Clover (*T. repens*), are valuable meadow plants; most of the others favour light soils or sandy ground. One, the

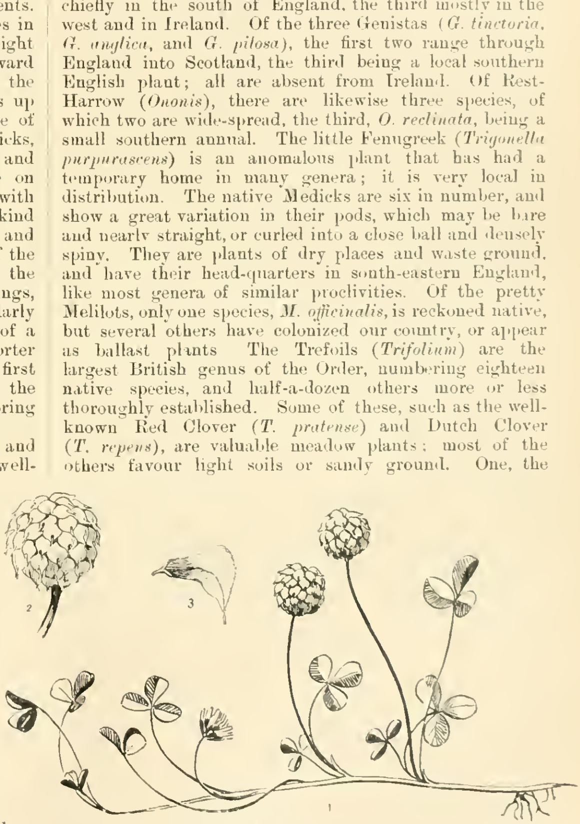


FIG. 5.—Strawberry-Headed Clover *(Trifolium fragiferum)*. 1, × ½; 2, natural size; 3, × 2.

curious Strawberry-headed Clover (*T. fragiferum*), chooses salt marshes; the fruiting heads of this species are rendered conspicuous by the way in which each calyx is inflated. Of Lady's-fingers (*Anthyllis*), the only British species is the well-known and widespread *A. Vulneraria*. *Lotus*, or Bird's-foot Trefoil, numbers five species, of which the rarest are *L. angustissimus* and *L. hispidus*, both confined to the south of England. The most familiar is the delightful little *L. corniculatus*, which adorns dry banks, especially near the sea, with its elegant glaucous foliage and umbel-like clusters of fragrant yellow blossoms.

The Milk Vetches (*Astragalus*) are three in number, and exhibit a great diversity of habitat, the first (*A. glycyphyllos*) being a large meadow plant, the next (*A. hypoglottis*) a small chalk species, while the third (*A. alpinus*), and *Oxytropis campestris*, which comes next on our list, are the only British species of the Order which affect an alpine habitat, both growing very sparingly on the Scotch mountains at an altitude of 2000 feet or more. *O. uralensis*, our only other representative of the latter genus, is a small Scottish hill plant, which ascends nearly as high as its congener. The genus *Ornithopus*, Bird's-foot, has two species, pretty little sand or gravel plants with pinnate leaves. *O. perpusillus* has a wide distribution, while *O. ebracteatus* grows on the Scilly Islands. The Horseshoe Vetch (*Hippocrepis comosa*) is a similar looking plant with curious wavy pods, wide-spread in England. The Sainfoin (*Onobrychis sativa*) is, like the last, the only British member of its genus. It is a handsome herb, a couple of feet in height, with pinnate leaves and racemes of rose-red flowers, in our islands confined to England, where it is not certainly native. Lastly we have the two large genera, the Vetches (*Vicia*) and Vetchlings (*Lathyrus*), which have been frequently referred to above. The climbing species generally grow, the lower among grass, the taller among shrubs, where they may attain in the season's growth a height of six or eight feet. The species devoid of tendrils grow in bushy form, or straggle upwards supported by neighbouring vegetation, or lie prostrate on the ground. The climbing species are the most picturesque of all our *Leguminosæ*. With their often winged ribbon-like stems, their graceful tendril-tipped leaves, and handsome clusters of blossom, they form delightful objects, and when we remember the beautiful and complicated structure of the flower, and the marvellous sensitiveness of the tendrils, we see and recognize in them some of the most highly developed forms to be met with in our whole native vegetation.

MICROSCOPY

Conducted by M. I. CROSS.

PHOTOGRAPHY OF OPAQUE OBJECTS.

By FREDERICK NOAD CLARK.

The method of procedure for this branch of Photo-micrography, in so far as the microscope is concerned, is practically the same as that for the photography of transparent objects. The difference lies chiefly in the mode of illumination, as well as in certain precautions to be observed in the mounting of the specimen, and in the purely photographic portion of the work.

At the commencement it is necessary that the object should appear in contrast to its background, the latter being selected with a view to this. A dark subject should have a light background, and *vice versâ*. For white objects, such as some eggs of insects, Foraminifera, etc., a disc of asphalt varnish placed on the glass slip with the turntable will be found suitable, the object being fixed thereon with a tiny spot of thin gum tragacanth. For darker subjects the under surface of a thick glass slip may be painted with white cement or enamel, the thickness of the glass minimising the effect of shadows cast by the illuminant. Should this not prove satisfactory a disc of white cardboard may be placed over the substage condenser a little distance behind the object, which in this case is mounted on a clear glass slip. Fair results may be obtained with specimens permanently mounted under a cover glass, but the best are made with those that have been freshly mounted without a cover.

Whenever possible objects should be photographed on their natural support. For example—the eggs of insects *in situ* on the larval food-plant, leaf, bud, calyx, etc., the educational value of the result being thus enhanced. This, of course, is not always possible, for frequently, as in the case of insects' eggs, the objects lie in different planes. When two or more objects in a group are photographed it is essential that they lie in a plane exactly at right angles to the axis of the microscope tube, or trouble will result owing to difficulties in focussing. The following plan may be recommended: fix the objects on a cork cut perfectly flat on the upper surface, having its sides tapered off so as to fit the opening in the stage, it may then be readily adjusted in any position. If the object is mounted on a glass slip this may also be attached to the cork.

Dark ground illumination is effected in several ways. One method is by using the central spot diaphragms, the smallest of these which will give the required dark ground being inserted in the substage condenser. The exposure of the plate will necessarily require to be long. Another method sometimes employed is the reflector known as the "Lieberkuhn." It, however, has disadvantages, as a separate one is required for each objective, and the mount must be specially prepared with a circular black spot on the under side of the glass slip. The illumination also is not satisfactory, being too "general," and delicate structure is flooded with light when contrast is required. Probably the best method is in the use of the side silver reflector, the rays from a good paraffin lamp being condensed on its surface by means of the bull's-eye condenser. Excellent results have been obtained simply by using the bull's eye placed obliquely towards the object, and as closely as possible. These methods are, of course, only applicable to low-power objectives, the short focal distance of the higher powers not admitting of their use. When photographing with the higher powers up to one-twelfth inch the "vertical illuminator" must be employed. This is a piece of apparatus fitted into the microscope tube above the objective, the light being conducted thereto through a small aperture in the side of the tube. When this is used the object must be either uncovered or in absolute contact with the cover glass. We will not notice such devices as the spot lens, paraboloid, etc., for obtaining dark ground illumination, they having been superseded by the methods just described.

(To be continued.)

POND-LIFE COLLECTING IN JANUARY.—January is the most severe month of the year, and lakes and ponds are often frozen over, or difficult to approach. Microscopic Pond-life, though less abundant than in the spring and autumn, is nevertheless nearly always present, even under the ice many inches thick. All the following species of Rotifers have been taken in January in and near London, but, no doubt, a great many more could be found by systematic search: *Asplanchna brightwelli* and *priodonta*, *Anuræa aculeata* and *cochlearis*, *Brachionus pala* and *angularis*, *Notholca scapha*, *Euchlanis deflexa* and *hyalina*, *Rotifer macrurus* and *vulgaris*, *Polyarthra platyptera*, *Synchæta pectinata*, *tremula*, and *oblonga*, *Conochilus unicornis*, *Coelopus porcellus*, *Diaschiza lacinulata* and *ventripes*, *Proales decipiens* and *petromyzon*, *Diglena forcipata*, *Dinocharis pocillum*, *Monostyla cornuta*, *Colurus caudatus*, *Melicerta ringens*, *Limnias ceratophylli*, *Oecistes crystallinus*, *Floscularia cornuta*, and *Stephanoceros Eichhorni*. *Diaptomus* and *Cyclops* and their larvæ are abundant, whilst Waterfleas are almost absent. Aquatic vegetation having died down, the fixed forms of Rotifers and Infusoria should be looked for on the rootlets of trees growing near the edge of the water. *Floscules* and *Melicerta* were once found covering such rootlets very thickly. January seems to be the time when the males of *Stephanoceros* and other tube dwellers are often found, and their presence is usually betrayed by the thick-shelled, fertilized, resting eggs in some of the tubes, and numerous smaller male eggs in others.

THE MICROSCOPICAL WORK OF 1902 has been steadily progressive; there have been no great changes or discoveries, although many additions to and improvements in the detail of instruments have occurred and been duly recorded.

A feature that stands out distinctively is the increased

amount of interest that has been taken in metallurgical work, a department in microscopy which is destined to exert a great influence on metal work generally. The capabilities of the microscope in this direction are not yet completely realised, and we may look for further development in the near future.

Among other items the two-speed fine adjustments have created interest and three or four new models of microscopes have been introduced.

There is, undoubtedly, better understanding of the proper uses and applications of the microscope, the substage condenser and the objectives, and when once the principles of critical illumination are thoroughly grasped and practised microscopical work generally will be uniform and far more trustworthy. It is but a few years since some degree of eminence was accorded to a well-known histologist for his investigations of certain structure, and the supposed discovery of new facts and detail which he demonstrated by photo-micrographs; yet it was evident to those who worked "critically" that the new features were almost entirely introduced by errors of illumination, and this was proved when his methods of working became known. Yet his dicta were accepted, reviewed and praised.

In another case a microscopist, who worked according to modern knowledge and practice, was being examined for a degree, and, amongst other things, was called upon to "spot" a subject which he had for several years studied and made especially his own. Owing to the indifferent method adopted by the examiner in illuminating and arranging the microscope, he failed to identify the specimen until he had bethought himself to re-arrange the setting up. I make special reference to this subject because it appears to me to be a real desideratum that microscopists shall work in the most precise manner that is known; it is only as work is accurately done that it becomes of real value.

In the conduct of a column such as this, the variety of information given and the general usefulness could be greatly increased by the co-operation of readers.

As mentioned in the December number, arrangements have been made for articles by several specialists to appear, but beyond this there are many readers who have made some special department the subject of study for a long period, and are in a position to give directions and advice which would be invaluable to other microscopists. Others have had constructed to their special ideas pieces of apparatus which they have found serviceable, or have distinctive methods of working which are not generally practised by others.

Among instances of these might be mentioned the method of showing a living fly in the act of feeding which was devised by the late Mr. Macer, and the beautiful colour arrangements which Mr. Rheinberg has brought to such perfection.

Communications are cordially invited, and aided by the consultants who have kindly placed their services at the disposal of readers of this column, I shall be happy at all times to give every assistance and advice in my power to those who may wish to avail themselves of it.

Wanted a Microscope Table.—In the November number suggestions were invited for a comprehensive microscope table, which could be closed and left with work in hand, ready to be proceeded with at some convenient subsequent time.

I have received several suggestions, but undoubtedly the best of all is the table which Mr. T. H. Russell, of Edgbaston, had built to his own ideas some years ago. An illustration of it is appended.

The following are its dimensions: Height, 2 ft. 5 in.; measurement of top, 15½ in. by 24 in.

It also has a hinged flap, suspended from the back of the table, 11 in. wide, on which mounting, etc., is done.

The table is fitted with a drawer which is divided into some eighteen compartments, similar to the plan shown. In this are contained dissecting instruments, cover glasses, glass slips, spirit lamp, saucers, and general accessories.

The loose wooden lid or cover, about 3½ in. deep, fits over the top of the table, and is provided with two locks, one at each end, by means of which it can be fixed to the top of the table, and thus covers any work which may be in progress. Two strong handles are fixed to the sides of the table for lifting.

This table has one great merit—simplicity—and would undoubtedly cover the requirements of four-fifths of the working microscopists. It will be readily seen that it could be made, if desired, at a very moderate expense, and modifications to suit individual tastes and requirements could be readily introduced.

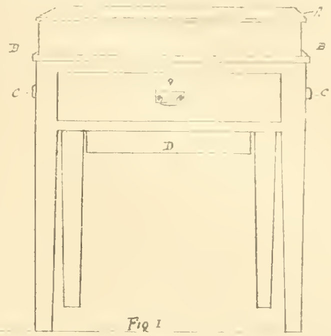


Fig. 1

A. Moveable cover; B B, Locks; C C, Handles; D, Flap.

For those who cared to do it, it would, of course, be possible to raise the lid by means of a pulley wheel attached to the ceiling and a weighted cord; and if it were desired to leave the microscope in position, the shape of the cover could be made so that it would go down over the microscope and lamp *in situ*.

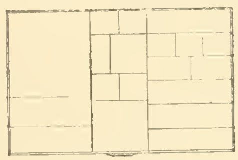


Fig. 2

Plan of Drawer, showing divisions.

To minimise vibration, the feet of the table could be inserted in sockets padded with india-rubber.

Our correspondent has in addition a cupboard in his hall where various articles such as a supply of water, bottles, and receptacle for waste water, etc., are always at hand.

Practical Scheme.—In continuation of the attempt made last year to foster practical work, material will from time to time be offered for distribution as hitherto. Through the courtesy of a reader I am able to offer some very interesting Spongilla and sponge spicules. A small supply will be sent to applicants on receipt of a stamped addressed envelope accompanied by the coupon to be found in the advertisement pages of this issue.

Mr. R. G. Mason, of Clapham, calls attention to his series of unmounted specimens, and has given me an opportunity of seeing the Limestone and Coal sections that he is advertising. The former would be found very useful to those who require practice in mounting; the prepared specimens are cleanly mounted and show interesting structure.

NOTES AND QUERIES.

C. M.—You are quite right, the deep curve of the crossed lens of an Abbe illuminator should be mounted downwards, that is, in the direction of the mirror of the microscope. The focus you mention is unusually long for an Abbe illuminator of correct form.

H. T.—I am afraid I cannot add to previous information. You ought easily to get a good black background under the circumstance you name, it is entirely a question of manipulation. Presumably you use the plane mirror. While you failed with the Abbe illuminator alone, there was a chance of something being wrong, but seeing that you do not succeed with a spot lens either, it seems certain that some little detail in your working is not attended to.

W. D. B.—The difficulty you mention of obtaining the same polarisation colour effects by artificial as with daylight is always a somewhat difficult matter. The only suggestion I can offer is that you set up a light filter consisting of a trough containing a blue medium of acetate of copper or ammoniacal solution of sulphate of copper, and then by varying the strength to find the tint which will give you the desired result. Perhaps some of our readers who do petrological work may know of some other and better method.

G. L.—I am afraid that I am unable to advise you in your attempt to prepare realgar specimens, the work is fraught with so much difficulty that it has been abandoned by nearly everyone; even those who do it professionally do not secure uniformity, some specimens keep for a number of years, while others decompose in a few days.

Communications and enquiries on Microscopical matters are cordially invited, and should be addressed to M. I. CROSS, KNOWLEDGE *Office*, 326, *High Holborn, W.C.*

NOTES ON COMETS AND METEORS.

By W. F. DENNING, F.R.A.S.

COMET PERRINE (1902 B).—This interesting object is now necessarily relegated to the care of observers in the Southern hemisphere, as its position renders it invisible in high northern latitudes. Moving somewhat rapidly in a S.W. direction it has recently traversed Scorpio and Centaurus, and will occupy a position in about 46 degrees south of the celestial equator on January 22, thereafter returning northwards and again exhibiting itself above our English horizon early in February. The comet approached comparatively near to the planet Mercury on the morning of November 30 last, when the distance separating the two bodies was equal to 1,644,000 miles. The following is an ephemeris by Stromgren:—

Date 1903.			R.A. H.	M.	S.	Declination S. °	′	Light
January	22	...	10	38	34	46	2	5·2
,,	26	...	9	46	17	43	58	4·7
,,	30	...	8	59	34	40	24	4·1
February	3	...	8	21	13	35	58	3·4
,,	7	...	7	51	16	31	16	2·7
,,	11	...	7	28	23	26	47	2·1
,,	15	...	7	11	2	22	42	1·6
,,	19	...	6	57	52	19	6	1·3
,,	23	...	6	47	54	15	58	1·0
,,	27	...	6	40	22	13	16	0·8
March	3	...	6	34	46	10	56	0·6
,,	7	...	6	30	53	8	54	0·4
,,	11	...	6	28	47	7	2	0·3
,,	15	...	6	28	49	5	13	0·2

After the first week in March the comet will finally disappear as an object for ordinary telescopes.

COMET TEMPEL-SWIFT.—No announcement appears to have been yet received as to the rediscovery of this comet. The calculations show that the present return to the perihelion has been much delayed owing to the disturbing action of Jupiter.

COMET SWIFT (1895 II.).—This comet was discovered by Lewis Swift on Echo Mountain on August 20, 1895, and though a faint object it was followed until February 5th, 1896, during which period about 400 observations were obtained. M. Schulhof has recently computed definitive elements, and remarks that "at the opposition of 1902 the comet will remain very faint; there may be hope, nevertheless, that it may be found with the aid of some of the more powerful instruments. There will be no possibility of observing it at its subsequent returns in 1910 and 1917. In 1924 its luminous intensity will be almost the same as in 1902, but the limits of uncertainty in its position will then be four times as great."

NOVEMBER LEONIDS.—Once more the month of November has come and gone without having furnished any striking meteoric spectacle, and it is now certain that the present generation must abandon all hope of witnessing a really grand exhibition of these meteors. Our experiences in and since 1898 have been singularly disappointing, and the (at least) temporary loss of the shower is to be deplored on several grounds. Its recurrence would no doubt have stimulated interest in the whole subject of meteors, while it would certainly have proved an incentive to the more thorough observation of these remarkable and numerous bodies. Apart, however, from special displays such as the Leonids occasionally produce it should be remembered that even on ordinary nights of the year the sky affords a vast and continuous exhibition of meteoric phenomena which patient and persevering observers may readily witness and record with pleasure to themselves and advantage to astronomy.

FIREBALLS.—November 3, 6h. Mr. H. M. Cross, of Scarborough, saw a very brilliant meteor shoot across the heavens from east to west, leaving a long streak of light behind it.

November 9, 7h. 20m.—Mr. Ivor F. H. C. Gregg, of Cambridge, observed a fireball about two or three times brighter than Venus, moving very slowly, and leaving a fine streak. Path from 154° + 57° to 132¼° + 54°; duration of flight, 4 seconds.

November 16, evening.—Very large meteor, with a trail of red light, seen at Berlin. The meteor burst low down in the western sky, and appeared like "a tremendous rocket."

November 25, 7h. 45m.—A splendid meteor, noticed by a casual observer at Bristol, moving rapidly in a north-west direction, and throwing off a long train of sparks.

December 2, 7h. 20m.—The Rev. S. J. Johnson, of Bridport, saw a meteor brighter than Venus passing slowly near the stars κ Draconis—ζ Ursæ Majoris. The meteor was greenish in colour, and it left a train. Duration of flight, about 2½ seconds. The observed course was from 187° + 71° to 203° + 57°, and the probable radiant near either α Persei or ε Arietis.

THE FACE OF THE SKY FOR JANUARY.

By W. SHACKLETON, F.R.A.S.

THE SUN.—On the 1st the sun rises at 8.8 A.M. and sets at 3.59 P.M.; on the 31st he rises at 7.44 and sets at 4.44.

The earth is at its least distance from the sun at 1 A.M. on the 4th; the apparent diameter of the sun being then at its maximum, 32′ 35″·06; the horizontal parallax of the sun is then 8″·95, also a maximum.

Small groups of sunspots may be expected from time to time.

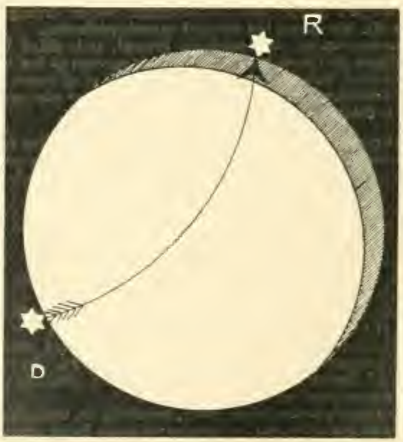
THE MOON:—

	Phases.	h. m.
Jan. 6	☽ First Quarter	9 57 P.M.
,, 13	○ Full Moon	2 17 P.M.
,, 20	☾ Last Quarter	11 49 A.M.
,, 28	● New Moon	4 39 P.M.

The moon is in perigee on the 13th, and in apogee on the 25th.

OCCULTATIONS.—The principal occultations visible at Greenwich are as follows:—

Date.	Star Name.	Magnitude.	Disappearance. Mean Time.	Disappearance. Angle from N. Point.	Disappearance. Angle from Vertex.	Reappearance. Mean Time.	Reappearance. Angle from N. Point.	Reappearance. Angle from Vertex.	Moon's Age.
			h. m.	°	°	h. m.	°	°	d. h.
Jan. 12	26 Geminorum	5·1	4 0 P.M.	37	74	4 30 P.M.	323	1	13 19
,, 14	60 Cancri	5·7	7 30 P.M.	163	202	7 55 P.M.	219	259	15 22
,, 14	α Cancri	4·3	8 14 P.M.	78	118	9 8 P.M.	306	344	15 23



Occultation of α Cancri.

The diagram shows the occultation of the 4th magnitude star α Cancri. The letters D and R indicate the points of disappearance and reappearance.

The Planets.—Mercury is an evening star in Capricornus; he attains his greatest elongation of 18° 45′ on the 18th, when he sets 1h. 45m. after the sun.

Venus is also an evening star, setting soon after the sun. On the evening of the 30th, when the planet sets at 6 p.m., she is in close conjunction with Jupiter, Jupiter being only 0° 44′ to the north; it is unfortunate that the planets set so soon after the sun, for it will only be possible to observe this exceptionally close approach in twilight.

Mars now rises before midnight; his path lies in Virgo, and on the morning of the 11th he passes to the south of γ Virginis by only a few minutes of arc. At 5 a.m. on the 19th the planet is in conjunction with the moon, Mars being 3° 35′ to the north. The gibbosity of the disc is considerable, the illuminated portion being 0·91 of the whole.

Jupiter is practically observable only during the first few days of the month, but the close conjunction of the planet with Venus on the 30th is interesting, and may possibly be seen in twilight.

Saturn is not observable, being in conjunction with the sun on the 21st.

Uranus is also out of range, being too near the sun.

Neptune is visible throughout the night. On the 1st he is very close to η Geminorum, having the same right ascension as the star, and being only 15′ to the south. Although the most distant of the planets, he hardly repays the trouble of finding; still it is an object that one wishes to have seen, and with the help of the accompanying chart the planet may be picked out from amongst the rich star-fields through which his path lies.

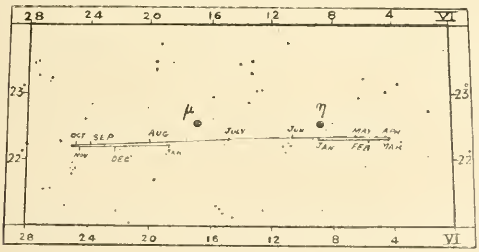


Chart showing path of Neptune in Gemini throughout the year 1903.

The Stars.—The positions of the principal constellations near the middle of the month at 9 p.m. are as follows:—

Zenith . Perseus, Auriga (*Capella*).

South . Pleiades, Taurus, Orion, with Aries and Cetus towards the S.W., and *Procyon* and *Sirius* towards the S.E.

West . Pegasus, Andromeda, Aquarius and Pisces; Cygnus to the N.W.

East . Leo (*Regulus*) low down, Cancer, Gemini (*Castor* and *Pollux*) high up.

North . Ursa Minor and Draco below *Polaris*, with Cassiopeia to the left and Ursa Major to the right.

Minima of Algol occur at convenient times on the 7th at 11.51 p.m., 10th at 8.40 p.m., 13th at 5.29 p.m., 28th at 1.34 a.m., and 30th at 10.23 p.m.

Chess Column.

By C. D. Locock, b.a.

Communications for this column should be addressed to C. D. Locock, Netherfield, Camberley, and be posted by the 10th of each month.

Solutions of December Problems.

No. 22.

Key-move.—1. P to B7.

If 1. . . . Kt to K2 (or R3),	2. Q to K8, etc.
1. . . . Kt to B3,	2. Q to B4ch, etc.
1. . . . K to K4,	2. Q to K8ch, etc.
1. . . . B to Kt7,	2. Q to B3ch, etc.

After 1. . . . B to B6 there is a *triple* continuation by 2. Q to B4ch, Q to B5ch, and Kt to Kt5ch.

No. 23.

Key-move.—1. B to Q5.

If 1. . . . R to Q6,	2. Q to QKt2, etc.
1. . . . P to K6 (or B to Q2),	2. Q × Rch, etc.
1. . . . R to QB6,	2. Kt × R, etc.
1. . . . R × P (or R to KR6),	2. Q to QKt2, etc.
1. . . . Kt to B5,	2. Q × R, etc.
1. . . . R to Kt6,	2. P × R, etc.
1. . . . R to Kt5,	2. R × R, etc.
1. . . . R to K6,	2. Q × R, etc.

There is a dual after 1. . . . B to Kt4, by 2. Q × Rch and Q to QKt2; and after 1. . . . R to QR6, by 2. Kt × R or Q to QKt2. G. Woodcock points out a pretty "try" by 1. Q to B7, B × Q (?), 2. Kt to B6ch, K to K3, 3. B to B8 mate.

No. 24.

Key-move.—1. Q to R6.

If 1. . . . K × P,	2. Q × QPch, etc.
1. . . . B × P,	2. Q to Rsqch, etc.
1. . . . P × P,	2. Q to R7ch, etc.
1. . . . Kt × Q,	2. Kt to K6ch, etc.
1. . . . Kt to Kt3,	2. Q × Ktch, etc.
1. . . . P to K6,	2. Kt to B3ch, etc.

Solutions received from W. Nash, 5, 6, 4; W. Jay, 4, 6, 4; G. Woodcock, 4, 4, 4; G. A. Forde (Capt.), 4, 4, 4; "Tamen," 4, 5, 4; C. Johnston, 4, 5, 4; "Looker-on," 5, 6, 4; J. W. Dawson, 5, 4, 4; Lieut.-Col. Damania, 4, 0, 4.

W. Jay.—Will you kindly send your address?

"*Tamen.*"—I have referred again to your solutions of the November problems, and find that your score (5, 4, 4) was correctly given. The only dual you pointed out in No. 19 (other than the short mate) was that after 1. . . . B × KtP. You did not give the dual in No. 20, and those in No. 21, according to the published rules, do not count. The faulty punctuation was, I think, a printer's error which escaped notice. Thanks for your reference to Knowledge of February, 1894. I am glad to find that the views therein expressed on the subject of dual short mates were in accord with the final decision given this year. The temporary decision given in July this year was certainly incorrect.

W. Nash. Your first letter reached me safely. Thanks for your news. Please say from what date you would like your year's subscription to commence.

The Solution Tourney for 1902 is now ended. Subjoined are the scores of those who attempted every problem:—

"W. Jay"	... ...	120
"Looker-on"	...	116
W. Nash	...	112
J. W. Dawson	...	100
C. Johnston	... ...	100
G. Woodcock	... ...	90
"Tamen"	... ...	78

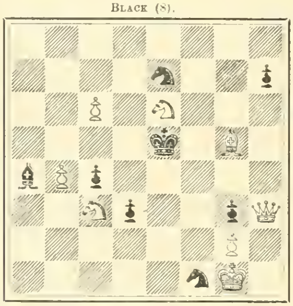
Any objections to the correctness of this score must be posted by January 10th. Failing this, Mr. "W. Jay" (W. J. N. Brown) becomes the first holder of the Challenge Trophy. Mr. Jay was second in the last Solution Tourney, after a tie for first place with Mr. Johnston. His score on this occasion shows how well he deserves his victory; out of a maximum of 121 he has obtained 120, the only point missed being for the dual in No. 22. The second prize (15s.) goes to "Looker-on" (G. J. Slater), who made a splendid uphill fight after losing three points in the first month. Mr. Nash, who obtains the third prize (Knowledge for twelve months) overlooked some duals in November, or would have been even nearer the others. Mr. Dawson solved every problem correctly, but was penalised once or twice for incorrect claims. Mr. Johnson missed two, but succeeded, nevertheless, in reaching the "century." Mr. Woodcock also failed on two occasions, and could, no doubt, have scored more for duals had he been so inclined. "Tamen's" score would have been considerably higher if his solutions had not been too late to count one month.

PROBLEMS.

No. 25.

"Inter pocula."

Black (8).



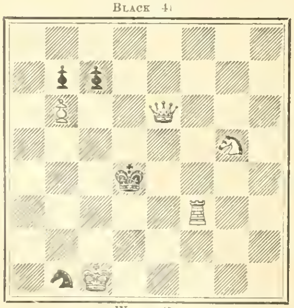
White (8).

White mates in three moves.

No. 26.

"Ben trovato."

Black (4).



White (5).

White mates in three moves.

The above are the last problems of the current Problem Tourney. It may be mentioned here that the order of publication has been decided by lot each month.

SOLUTION TOURNEY, 1903.

This year's Solution Tourney commences in the present number of Knowledge, and will continue till the end of the year. The winner will hold for twelve months the Knowledge Challenge Trophy. This will become the property of any solver who wins it three years in succession, or four years altogether. In the event of a tie, the previous holder will retain possession of the trophy; in that case, however, neither a win nor a loss will be scored to the holder.

The second prize will be 15s., and the third prize Knowledge for twelve months. In the event of ties for either or both of these, the ties shall be decided by a further trial of skill under new conditions, or the prizes divided at the discretion of the Chess Editor.

The problems published will be either three-move or two-move direct-mates, and not more than two will appear in any number. In the event of any problem being incorrectly printed, it will be cancelled and reprinted. Points will be awarded as follows:—

Two-move Problems.—Any one correct key, 2 points; a *second* solution, 1 point.

Three-move Problems.—Any one correct key, 4 points; a *second* solution, 2 points.

One point will be deducted for any one incorrect claim for a second solution. A correct claim of "no solution" will count as a correct key.

Special Note.—Duals will not score *after this month*, when the Tourney Problems come to an end. All solutions must bear postmark of the issuing office not later than the 10th of the same month.

CHESS INTELLIGENCE.

Another small tournament among the Parisian experts has just been concluded, M. Silbert on this occasion joining the competitors in the previous tourney, which was won by M. Janowsky. This time M. Taubenhaus succeeded in sharing the first and second places with M. Janowsky, their scores being 4½. M. Albin scored 4, and M. Silbert 1½. Herr von Scheve retired in the middle of the competition, his score at the time being 1½.

The British Chess Club being now, as a separate institution, defunct, the management of the Anglo-American Cable Match will in future be in the hands of the City of London Chess Club. The date of the match will depend on that of the conclusion of the Monte Carlo tournament. It is hoped that the transmission of the moves will be effected by means of wireless telegraphy.

All manuscripts should be addressed to the Editors of Knowledge, 326, High Holborn, London; they should be easily legible or typewritten. All diagrams or drawings intended for reproduction, should be made in a good black medium on white card. While happy to consider unsolicited contributions, which should be accompanied by a stamped and addressed envelope, the Editors cannot be responsible for the loss of any MS. submitted, or for delay in its return, although every care will be taken of those sent.

Communications for the Editors and Books for Review should be addressed Editors, Knowledge, 326, High Holborn, London.

For Contents of the Last Two Numbers of "Knowledge," see Advertisement pages.

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CONTENTS.

CROSS-FERTILISATION IN SOCIOLOGY.—I.

By J. Collier.

The assertion was perhaps first made by Niebuhr, repeated by Whately, and supposed to be very damaging to the alleged evolution of the higher races of man from the lower, that there is no instance on record of a savage people raising itself unaided from barbarism to civilisation. Might not the criticism be generalised? Can it not be affirmed that there is no recorded example of any people rising considerably in the scale of culture otherwise than by receiving stimulation, amicable or hostile, from other peoples? For it may happen in two ways. A man is "made by his enemies," like Mr. Chamberlain, and nations have been brought to the point of self-conscious individuality, as happened to England and France, to France and Germany, by mutual animosity. French and English historians agree that the latter stages of the French Revolution were initiated by the hostility of coalised Europe. But wrath and hatred are not at the base of collective any more than of individual life; the chief social regenerator is love, and in its primary form. The floral world has been finely shown to owe its beauty and magnificence to cross-fertilisation; the animal world might likewise be shown to be indebted for its vigour and variety to intercrossing. So might it be proved that most great advances in civilisation have been originated by the blending of two stocks, the immigration of individuals from one society to another, the temporary migration of individuals to other societies, the transmission of germs from one society to another by various agencies, or by the reaction of one portion of a community on another, or of one form of social life on another. These are, all of them, robust or "degraded" modes of intercrossing or cross-fertilisation.

Cross-Breeding in Philosophy.

A rapid sketch of a single line of development will reveal something of the part that this great natural agency has played in history. All the leading philosophies have been born of the contact of alien ideas with native systems. Platonism was begotten by the soaring speculations of the Italian Eleates on the stubborn realism of Socrates. Aristotle was formed by opposition to his master and by a species of intercrossing; in him metaphysic was, as it has all along been, fertilised by contemporary science. Pantheistic Stoicism was the offspring of Asiatic thought on Greek thought; Deistic Epicureanism of atomistic science on the same basis. Greek Eclecticism consisted of a medley of systems intermingled by Syrian, Phœnician, Greek, and Roman thinkers. Neo-Platonism blended Aristotelianism and Platonism with an Oriental admixture. Mediæval Scholasticism was the outcome of Aristotelianism applied to Christian theology. The scientific discoveries of the seventeenth century bred an original philosophy equally on the sympathetic Scholasticism of Descartes and on Hobbes's antagonism to Scholasticism. Cartesianism generated Spinozism on the traditions of the Cabbala. Spinozism introduced the new element of immanence into the philosophy of Europe. Kantism was begotten by the scepticism of Hume on the metaphysic of Wolf and Tetens. The cloudy transcendentalism of Schelling was the phantom produced by the union of Oken's pseudo-science with Kantism. The old French philosophy took on a new character in Royer-Collard under the influence of Reid. Victor Cousin owed his originality to an early infusion of German doctrines. Hamilton repaid Kant's debt to Hume by affiliating himself on Kant, with Reid for matrix. Ferrier reared a bright castle-in-the-air under the inspiration of Berkeley. And Mr. Spencer acknowledges that a formula of von Baer was the starting-point of his evolutionary (and revolutionary) career.

These are the blue gentians and the gorgeous water-lilies of the speculative reason, and, like their vegetal analogues, they owe their brilliancy to the mingling of diverse stocks. What a self-fertilising philosophy may come to we see in later lifeless Scholasticism. Wooden Dutch philosophy after Spinoza, the sounding inanities of Italian philosophy between Vico and Vera, the dull platitudes of Scottish philosophy from Dugald Stewart to McCosh, later Spanish philosophy, and the orthodox official philosophy of all countries. These are the useful grasses and useless sedges of thought, whose small, pale, etiolated blossoms do not minister delight or attract the wayfarer.

Mass-Fertilisation.

All through Nature the male seeks the female. The masculine peoples—the Greeks for a time, the Romans pre-eminently, the Spaniards of the sixteenth century, the English of the last three centuries, and now the Russians—have spread themselves over the world in search of

feminine peoples to be conquered or civilised. The effect they produce is proportionate (1) to the prepotency of the aggressive element, and (2) to the amount of it. The Macedonian highlanders, reinforced by Greeks from the islands and the two mainlands, who Hellenized Asia and Egypt under Alexander and his successors, cannot have been very numerous, but their propagandist energy and intellectual superiority raised their prepotency to the highest point ever attained. Accordingly, they diffused Greek culture over a large part of the East, developed Greek philosophy and science, and prepared a theatre for the reception of Christianity. Cosmopolitan Alexandria, in particular, was at once a menstruum of nationalities, and the scene of the fusion of Oriental and Occidental thought.

It is estimated by M. Jullien that the colonists settled in Gaul by Julius Cæsar and Augustus did not exceed thirty thousand. Add merchants, artizans, functionaries and slaves, and the total may still be inconsiderable. Yet with this limited material, the world-moulding people modelled Provence in its own image, and from this base it Romanised Northern Gaul, Western Germany, and Southern Britain. The Roman talent for government made the Romans as prepotent morally as the Greeks were intellectually.

In northern Gaul the Franks were more prepotent than their Visigothic kin in the south, and probably more numerous than the Romans there. They yet created no new ethnical type, but only reinforced the fair dolichocephalic element. They strengthened the characters of energy, firmness, and seriousness in the Gaulish temperament. They did not produce the feudal *régime*, but they contributed the fructifying pollen which developed it out of existing usages, thus made it inevitable, and added to it certain features that were peculiar to themselves. Mediæval chivalry was the offspring of the marriage of the German with the Gaulish minds. The key to French history lies in the perception of this periodic cross-fertilisation. We observe it again in the abortive Reformation of the sixteenth century, in the critical movement of the eighteenth century, in French philosophy under Louis Philippe, in the French literature of the sixties, and French science of the nineties.

The numbers of the Saracen invaders of Spain are stated at twenty-two thousand; these were doubtless largely increased by later immigration, but seven centuries afterwards they did not exceed two hundred thousand. Yet their influence on Visigothic Spain was deep and has been lasting. By constant intermarriages they created a new ethnical type, of mixed Arab and Spanish blood. Is the ferocity of the Spanish character, as plainly shown in its saints as in its hidalgos, in its religion as in its conquests and its sports, derived from the foundation of savagery in the Semitic nature? They modified the physical environment by erecting public buildings and constructing a system of irrigation that are still in use. They established the culture of silk and sugar. They transmitted the manufacture of paper and of gunpowder, and the binding of books. They changed the face of pharmacy and medicine. They diffused over Europe the Arabic numerals, algebra and the higher mathematics. Heeren asserts that they made no important discovery, but others allege that they originated the germs of many later discoveries. They deeply affected the vocabulary, the literary forms, and the spirit of Castilian literature. Their influence on philosophy can be definitely stated. They translated the works of Aristotle from the Syriac versions, not from the Greek. The Arabic versions were translated into Hebrew by the Jews, whose translations were translated into Latin. Aristotle four times decanted was the only Aristotle the early Schoolmen knew. Aristotle was commented on by Arabian Averroes; Averroes was commented on by Jewish Maimonides; and from these blended sources Greek-Arabic-Jewish speculations flowed into mediæval Europe by influencing Alexander of Hales, Bonaventura, and Albertus Magnus, the earliest Schoolmen. In all these ways the Arabians communicated fresh vigour to the European intellect.

The little band of Normans who conquered Calabria and Apulia consisted of no more than twelve hundred horse and foot, though in twenty years it swelled to the legendary total of sixty thousand. We should expect their prepotency to have been more military than intellectual or commercial; yet they set up the earliest medical school in Europe, and founded the city that first distributed the products and manufactures of the East. To Sicily the same conquering race transported from Athens, Corinth and Thebes, a captive multitude of silk weavers and artizans, who planted new industries in Italy. To England it brought the seeds of new institutions, new arts, new philosophies and theologies. The history of our own country strikingly illustrates the Darwinian principle that a social organism crossed, though at distant intervals, with kindred varieties, gains vigour and fecundity.

Group-Fertilisation.

Countries are fertilised by groups as well as by masses. In the third century Germany received the first seeds of Christianity at the hands of Roman refugees from persecution; and at the same time a multitude of Roman provincials, captives of the Goths, diffused the same religion in Dacia among their masters, whose apostle, Ulphilos, invented the Gothic alphabet. In the sixth century the bigotry of Justinian drove thousands of his industrious Nestorian subjects from all provinces of the Eastern Empire, whence they carried into Persia the arts alike of peace and war. About the middle of the eighth century Constantine Copronymus transplanted the sect of Paulicians from the banks of the Euphrates to Constantinople and Thrace, where they introduced and diffused the germs of Protestantism. They were strengthened by a second and larger contingent, transported two hundred years later from the Chalybian hills to the valleys of Mount Hæmus. They spread from Bulgaria, Croatia and Dalmatia, into the Greek provinces of Italy and Sicily, whence they silently propagated their opinions as far as Rome and Milan. In the south of France they were known as the Albigeois, whose bleeding remnants bore their faith into Northern France, England, Bohemia, and Germany. An unbroken chain thus links the second founder of Christianity to Wickliffe and Jerome, Calvin and Luther. The exiled French Huguenots conveyed to Prussia the secrets of several lucrative industries, and (according to Laveleye) communicated to the Berlin mind the vivacity and precision that have aided it in gaining an ascendancy over the vague and dreamy spirit of Germany. They brought to England sugar refining, and introduced improvements in the paper manufacture. But the best gifts are men. The Huguenots took to Germany the ancestors of Savigny, who founded a new school of law and a new method—the historical method, and Beausobre, who initiated a new species of history—the history of doctrines. To England they brought the "dissidence of Dissent, and the Protestantism of the Protestant religion" in an ancestor of Edward Miall; in an ancestor of James Martineau, that "purer and more perfect theism" to which Gladstone believed that religion would one day be reduced; while his sister, Harriet, was the masculine expositor of an

enlightened secularism. These were the developments of Protestant germs. In John Henry Newman the sturdy Huguenot stock may not seem to have been prepotent; but the priest who denounced the "insolent and aggressive faction" that forced on an Ecumenical Council the definition of the dogma of Papal infallibility, like the cardinal who kept the *Decline and Fall* constantly on his desk, must have remained a Protestant at heart.

ST. SOPHIA, CONSTANTINOPLE.

By E. M. Antoniadi, f.r.a.s.

Illustrated from original drawings by the Author.

I.

Introductory.

There is much to attract the archæologist in the city of Constantine. Gigantic ruins of land and sea walls; towers picturesquely invaded by luxuriant vegetation, and cracked by frequent earthquakes in a geologically wavering soil; imposing remains of once garish palaces; magnificent churches, often preserved intact; monumental aqueducts; vast cisterns; and inextricable subterranean labyrinths, are as many fascinating subjects of study to the inquisitive mind.

During his long stay in Constantinople, the writer took some interest in archæology, but only as a recreation from business and astronomical observations. It was at once felt, however, that the subject of Byzantine antiquities, as a whole, was too vast to be seriously undertaken; and that the justification for any claims to originality in the final results involved a strict specialisation of the enquiry in a limited domain of mediæval Greek architecture.

St. Sophia, the splendid cathedral, and now the great mosque of Constantinople, presented a particular attraction to the writer through the mystery veiling its former condition, and, especially, its inner division as a Christian church. From 1889 to 1893, he visited that celebrated shrine hundreds of times, and took accurate plans, sections and elevations of it, as well as a very large number of drawings of its appearance. These data have been further completed and checked by photography; so that the equipment for understanding the text of the Greek historians in the light of the present building was as satisfactory as could reasonably be expected.

Much assistance was received at the time from the late Canon Curtis, of the Crimean Memorial Church, Constantinople; while the disinterested willingness of the Turkish guides of the mosque in giving honest and valuable information was most welcome and gratifying.

Historical Notices.

The foundation of a church dedicated to the Holy Wisdom, or to Christ himself, is attributed to Constantine the Great. It appears that the structure was begun towards 326 A.D., and that its dedication did not take place before 360, in the reign of Constantius. The form of the first church was that of the basilica type, probably with three naves covered with barrel vaults, the central vault resting on two rows of columns. Burned partly by the partisans of St. John Chrysostom, who was banished from the city in 404, and again restored by Theodosius the Younger in 415, Constantine's church was at last totally destroyed by fire in the Nika riot of 532.

The quell of the rebellion raised Justinian to the acme of power. His ambition was to reconstruct the church in such splendour as to transcend anything ever achieved before; and the unrivalled genius of his architect, Anthemius of Tralles, enabled the emperor to produce a building which, in originality of design, audacity of structure, and gorgeousness of decoration, has never since been equalled, or even approached. It was only thirty-nine days after the fire that Justinian undertook the reconstruction, and he pushed the work with such relentless activity, that the present building was completed and opened in the incredibly short space of not even six years; the dedication actually taking place on Christmas Day, 537.

The 1365 years separating us from the dedication saw vast changes in the appearance of the church. In the first place, the original dome, which was twenty feet flatter

Fig. 1.—St. Sophia at sunset, with light streaming through the Dome. (Appearance of the Mosque towards 1455, at the completion of the Minaret erected by Mohammed II.)

than the present one, fell in 558 through the effects of repeated earthquakes, and it was thought safer, in its reconstruction, to check somehow the thrust by raising the curve to a greater height. The second dedication under Justinian took place once more on Christmas Day, 563, seven years before the birth of Mohammed.

An adumbration of the subsequent history of St. Sophia may be given as follows:—

A.D. 620±. At the critical moment of the war between Heraclius and Chosroes the Church comes nobly forward and saves the State, by coining many of the treasures in its possession.

628. Heraclius lifts in triumph the wood of the True Cross before the altar of St. Sophia.

725. Leo the Isaurian issues his first edict against image worship.

741. Great Earthquake of Constantinople.

842. End of the Iconoclastic controversy; triumph of Orthodoxy.

865. Erection of a belfry near the west front of the church.

869. Earthquakes; the vaulting cracks in several places.

869–870. Eighth Œcumenical Synod, held in south aisle of first floor level of St. Sophia.

875±. Basil the Macedonian, consolidates the great arch to the west by an additional thickness.

975. A strong earthquake shock causes the western arch of St. Sophia to totter, and to drag the dome in its fall.

981. Basil II. restores the fallen parts.

987. The ambassadors of Wladimir are so dazzled by the grandeur of the divine service in St. Sophia that they

decide the conversion of the Russian nation to the Orthodox Greek Church.

1054. The envoys of Pope Leo IX. excommunicate the Eastern Church on the great altar of St. Sophia.

1204. Capture of Constantinople by the Crusaders. Wanton profanation of the sanctuary by the soldiery. Baldwin, of Flanders, is crowned first Latin Emperor of Constantinople in St. Sophia, which is converted into a Roman Catholic church. The *Te Deum* resounds in the dome for fifty-seven years.

1261. Constantinople is reconquered by the Greeks and St. Sophia restored to the Orthodox faith.

1317. Andronicus Paleologos, the Elder, erects the huge buttress masses disfiguring the outside.

1346. Earthquakes. Collapse of the great eastern arch and of all that part of the dome resting on it.

1360±. Restoration of the vault by John V. Paleologos.

1452. A *Te Deum* is again sung in St. Sophia, by order of the last Constantine. But this alienates the sympathies of the people, who, from that day, avoid the church as a Jewish synagogue or a heathen temple.

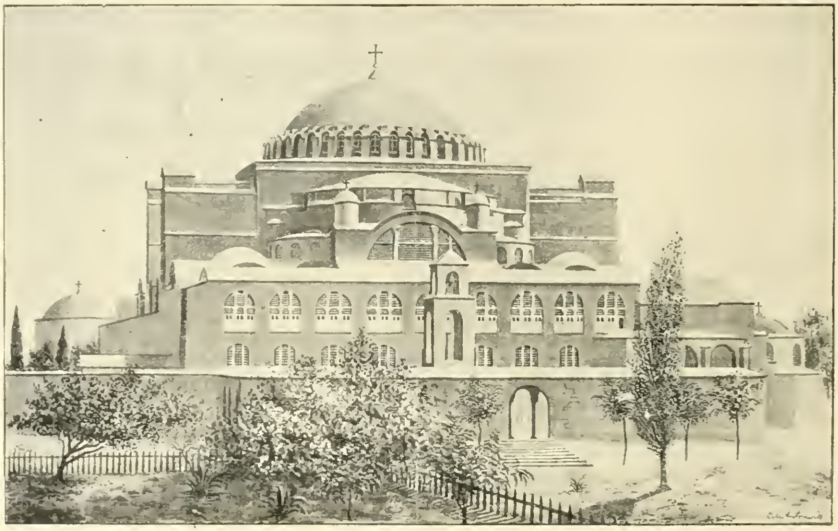


FIG. 2.—The West Front of St. Sophia, towards 870 A.D.

1453. Fall of Constantinople. Mohammed II. respects St. Sophia, which he solemnly dedicates to Islam.

A few words regarding the treatment of St. Sophia by the Turks would form a fitting conclusion to this brief historical sketch. Contrary to what is generally believed, the building did not suffer much from its new masters. The damage reduces itself to the partial scratching of the arms of some crosses in bas-relief and to the whitewash cover of the majority of the mosaics. Many mosaics have been removed as a measure of precaution, through the cracking and precariousness of the mortar in which they were fixed. This toleration for images whose representation is forbidden by the faith was attended with a pious zeal towards the preservation of the building. In 1573, Sultan Selim II. repaired the eastern arch; in 1847-1849, Sultan Abdul Mesjid spent nearly a quarter of a million sterling for a general restoration, while the first care of his son H.I.M. Sultan Abdul Hamid II., after the earthquake of 1894, was to appoint a commission of architects in order to study the damage, and to at once order a general repair. It is only fair, therefore, to acknowledge the great debt of gratitude we owe to the Sultans of Turkey for having preserved to the archæologist, practically intact, the grandest architectural conception the world has seen.

DESCRIPTION OF ST. SOPHIA.

The following description is a very condensed *précis* of some of the writer's conclusions regarding the former condition of St. Sophia. The illustrations are, of course, invariably original, and rest on data obtained either in sight of, or within the mosque. For the artistic effects of Figs. 1 and 2, the writer is indebted to his friend, Mr. Shirley Fox, R.B.A., whose valuable suggestions have been most welcome.

The Orientation.—This is $33\frac{2}{3}°$ south of east.* Labarte thought† this direction was given in order to render the new edifice parallel to the already existing structures of the Imperial Palace of Constantinople. The writer takes

* During his stay in Constantinople last summer, the writer found that the axis of St. Sophia, as determined by him from Kadikoy, formed an angle of 127° with the magnetic north. Messrs. Crommelin and Nash, of the Royal Observatory, Greenwich, were kind enough to give him the value, 3° 20′ West, of the declination of Constantinople for 1902. This value has been computed from a German magnetic map of the earth for 1885 and cannot be trusted to the minute. We thus have for the orientation—

$$127° - (90° + 3° 20') = 33° 40'.$$

† *Le Palais Impérial de Constantinople et ses Abords*, p. 18. Labarte commits a grave error in affirming that "it is very important to state that the major axis of the Hippodrome and the major axis of St. Sophia produced, form a right angle at their intersection." This angle actually has a value of 105°, and it is impossible to see how it could ever have had another value. Labarte's work is eminently misleading; but is it not hard to accurately describe from the rooms of a western library, a building 1400 miles off, and of which every trace has long since disappeared?

THE CHURCH OF THE IMMORTAL WISDOM.

Panoramic View of the Interior from the Stall of the Empress in the West Gallery. Epoch 538 A.D.

this to be a very superficial view of the question, as it is hardly likely that the orientation of such a shrine could have ever been subordinated to that of some disjointed pavilions. In their excellent work, published in 1894, Messrs. Lethaby and Swainson show a much clearer grasp of the problem. "The axis of the church," they say, "seems to point somewhere between 30° and 35° south of east, where there is a considerable sea prospect and a low horizon. This direction, either by accident or intention, must agree very closely with sunrise at the winter solstice." They further call attention to the fact that "Justinian's church was opened at Christmas."* These pregnant remarks lead to a solution of the difficulty. But for this it is necessary to bear in mind:—

(*a*) That Procopius lays stress on the fact that "the face of the church was directed towards the rising sun, in order to have the sacred mysteries performed in honour of God";

(*b*) That $33\frac{2}{3}°$ south of east is the azimuth of the sun having entirely risen above the Bithynian Mountains at Christmas; and

(*c*) That the church was dedicated to the Second Person of the Trinity, the anniversary of whose birthday occurred very near the winter solstice.

The idea of the $33\frac{2}{3}°$ is thus rendered unmistakably clear: *The sanctuary was to face the sun just risen on the birthday of Christ, to whom it was dedicated.*

Outer Appearance.—Owing to the unrivalled audacity of its construction, as well as to the formidable thrust of its dome, St. Sophia could never have been a really graceful building on the outside. It is even to be feared that, through the still greater flatness of the first cupola, the original form of the church was more disappointing than the present one. Evidently, the early Byzantines attached no great importance to the exterior view of their churches. Outer pomp had to be entirely subordinated to the requirements of inner harmony. All they seemed to have cared for was to have roofs of easy access; and it was doubtless to this end that steep outside curves were assiduously discarded. At the same time, the combination of both outer and inner splendour in the self-same building is a question which the mediæval Greek architects did not attempt to decide. Nor has the problem received a satisfactory solution since their time.

The mortar which covers the brick walls of St. Sophia is doubtless less attractive than the fine naked stone walls of other churches. But while rain and the molecular work of heat and frost tend, in the long run, to decay any stone exposed to their action, the mortar, if only carefully repaired, plays the part of a barb against the disintegration of the active structure beyond. That is why the walls of St. Sophia are still young, though nearly fourteen centuries old; and if they failed on some points, it is to other causes, not to exposure, that the failure ought to be attributed.

A large cross stood at the top of the dome. Indeed, this axiomatic truth would not have been mentioned here were it not to have been questioned by Messrs. Lethaby and Swainson. "Salzenberg," they say, "assumes from Paulus, that 'the dome was surmounted by a cross'; the cross was of mosaic inside."* The authors have been led into error by a misinterpretation of the following verse from the Silentiary's poem:—

75. . . . . . . Ἀκροτάτης δὲ
76. Σταυρὸν ὑπὲρ κορυφῆς ἐρυσίπτολιν ἔγραφε τέχνη,

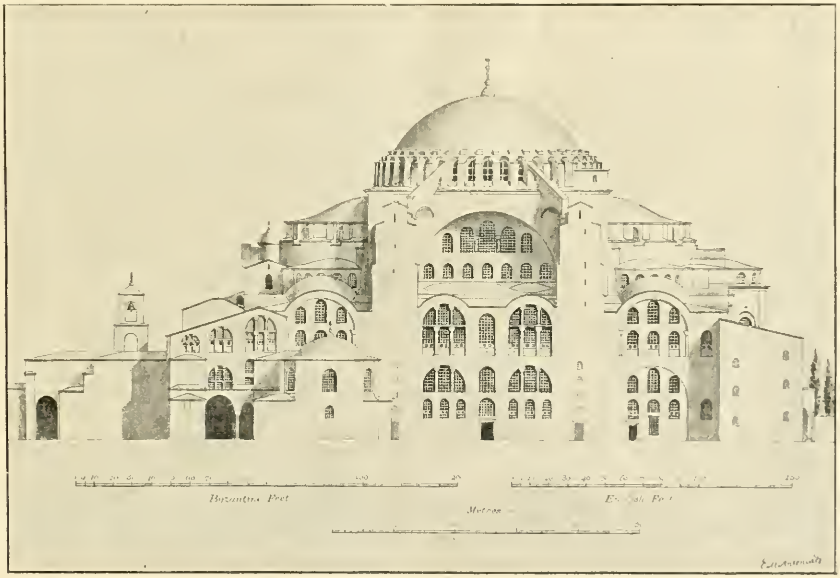


FIG. 3.—The South Elevation of the Great Church. Epoch: 1300 A.D.

* *S. Sophia, Constantinople*, p. 17.

* *S. Sophia*, footnote to p. 160.

which, translated into English, becomes :—

"Above the highest summit art figured a cross, guardian of the city."

Messrs. Lethaby and Swainson remark that "ἔγραφε leaves no doubt that a mosaic cross on the interior is intended."* It is quite clear, however, that the expression "*above* the highest summit" could never apply to an inner cross in mosaic. A real picture is always *on* the surface of the material on which it is depicted; it can neither be *above* nor *below* that surface. Hence no mosaic cross, visible from the floor, could ever have been *above* the spherical surface on which it was drawn; it must necessarily have been *on* that surface. But in the case of a solid cross, erected on the outside, the *above* is welcome, inasmuch as the cross then rises over the outer surface of the dome. These arguments render impossible the meaning of *painted* to ἔγραφε, as, in that case, the painting would have to be effected on empty air, a few feet above the top of the cupola. An English equivalent to ἔγραφε, applicable to a solid cross cast in metal, is *figured;* and, with its adoption, everything is plain sailing. Another argument, but of an indirect bearing on the point at issue, is that a cross on the dome of a great cathedral would guard the city somewhat indifferently if painted in the darkness of a vault. The watch would be much more effective if the guardian could be given a chance of seeing what he was guarding, and be seen from it; the people would rejoice in the idea of seeing their palladium from a distance in the city.

A careful synthesis of historical facts will enable us to undertake a fairly trustworthy restoration of the outer appearance of St. Sophia at one of the most flourishing periods of Byzantine history, at the time of Basil the Macedonian, in the ninth century. Adding the bell tower erected here in 865 by the emperor Michael in order to receive the bells presented to him by the Doge of Venice, and actually seen in position by Grelot towards 1679; restoring the steps of the atrium; liberating the western arch and semi-dome of their additional thicknesses; also giving the west wall† and the dome their original appearance, we unmistakably launch on something like Fig. 2, where the only weak point lies in our ignorance as to the number of arched openings piercing the atrium wall on the west side. A similar treatment of the south façade, but for a more recent date, led the writer to the elevation shown on Fig. 3. Apart from the omission of the buttress masses erected in 1317, this elevation differs from the present view of the mosque in some other particulars, such as the saddle roofs of the little chambers at the buttress tops; the restoration of a room at the top of the staircase on the south-east angle of the great platform; and the insertion of two buttress arches reaching up to the windows of the cupola. It was during the 1847–1849 restoration that the roofs of the chambers were rendered cylindrical; that the corner room and buttress arches were removed, the office of the latter being taken advantageously by a double cincture of iron round the base of the dome.

* *Ibid*, p. 42, note.

† It was thought safe to buttress the dome on the west at an unknown period of the church's history, and this was done by lengthening radially thirteen of the piers between the upper windows. But there was not enough space between the edge of the central western piers and the edge of the west wall, so that the work entailed a thickening of the latter. This thickening is, therefore, not original, and it does not exist to the east, so that its representation in "original forms" of the church by M. Choisy, as well as by Messrs. Lethaby and Swainson, is doubtless attributable to some sort of error.

(*To be continued.*)

THE CHEMISTRY OF THE STARS.

I.—INTRODUCTORY.

By A. FOWLER, F.R.A.S.

It is a striking fact that more is known with certainty as to the substances which help to build up the sun, and the still more distant stars, than of the materials which exist at depths greater than a few miles below the surface of our own planet. As to the interior of the earth, we can in no way examine any portion of it, and can only speculate as to what may be there by reasoning from such facts as the known increase of density as the centre is approached. In the case of the heavenly bodies, however, we have at least the advantage of being able to see them, and it is in fact upon the spectroscopic analysis of the light which they radiate into space that our knowledge of their chemical composition is founded.

The general principles involved in the identification of the substances composing the heavenly bodies may be summed up in a few words. An incandescent gas or vapour sends out rays of light having definite wavelengths, whether it be raised to incandescence in a laboratory experiment or by the conditions to which it is subjected in sun, star, or nebula; so that all that seems necessary is to find by trial which of the substances open to experiment emits rays corresponding with those of the body under investigation. This analysis of light is of course carried on by the use of a prism or diffraction grating, by which means the rays are dispersed into their component elementary waves, and as the light is usually first passed through a narrow slit, each of these components is represented by a "spectrum line" of definite colour and position. An interesting example of this process is illustrated by Fig. 1, which shows how the presence of helium in Nova Persei, at one stage of its history, was established by comparing its spectrum with that of helium enclosed in an ordinary vacuum tube, and rendered luminous by electric discharges.

D_3.

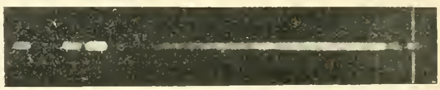


FIG. 1.—Spectrum of Nova Persei, 1901, August 11, with Helium comparison, showing coincidence of the D_3 line. (Lick Observatory.)

Usually, however, the direct radiations of the substances composing the heavenly bodies cannot be observed. Thus, the light of the sun, and of the great majority of the stars, exhibits dark lines on a coloured background when analysed by the prism, but the far-reaching discovery by Kirchhoff that incandescent gases and vapours absorb light of the same wave-lengths as they themselves emit at the same temperature, shows that the dark lines are just as distinctive as the corresponding bright ones, so that the chemical origins of dark lines may be investigated by the process of matching employed in the case of bright lines.* An example of this is given in Fig. 2, which shows how the presence of iron in the sun is demonstrated by the coincidence of numerous dark solar lines with as many bright ones of the metal, the source of light in the latter case being an electric arc lamp having poles consisting of iron rods.

* A general summary of the principles of spectrum analysis, and an account of experiments illustrating them, will be found in KNOWLEDGE DIARY for the current year.

It will be seen that not only is there a coincidence in position of the bright with dark lines, but also a remarkable agreement in the intensities of the two sets of lines—the brighter the bright line the more intense the dark one.

It is quite evident that the chemistry of the heavenly bodies can only be investigated by combining the work of the laboratory with that of the observatory. In the

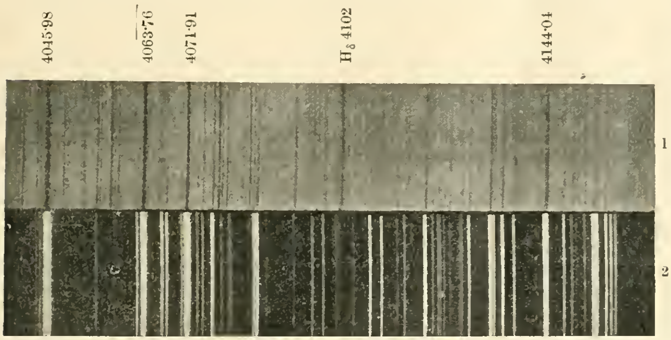


Fig. 2.—A small part of the Spectrum of the Sun compared with that of Iron.

laboratory the spectrum of every known substance must first be carefully mapped out, and the lines tabulated, for ready comparison with the spectra encountered in the observatory. In either case, the most convenient mode of procedure is to record the spectra photographically, as in the two illustrations already given. When a spectrum has been once photographed, it can be re-examined at any time without further experimental preparations, and in some cases, as in that of Nova Persei, a permanent record is secured when the opportunity only occurs once. In dealing with faint objects, the photographic method has the additional advantage of integrating successive impressions, so as to effectively increase their apparent brightness, whereas the eye can only take account of momentary effects of the rays of light, and does not see the lines any brighter by continued observation.

It is scarcely necessary to explain in detail here the methods employed in the practical observation and mapping of spectra, but there is one point of fundamental importance upon which a few remarks may not be superfluous. Although experience may render the observer so familiar with the spectra of different substances that he can often identify lines by mere inspection, careful measurement can usually alone give satisfactory results. It is evidently necessary, therefore, to adopt some system of stating the positions of the lines by which chemical substances are identified, which shall be applicable to spectra observed with any instrument whatsoever, in order that all records may be strictly comparable.

In practice, the positions are stated on a scale of wave-lengths, the number attached to each line then representing the length of the waves of light which produce the line. These waves are excessively small, but they can nevertheless be measured with great accuracy by the use of diffraction gratings. They are so small that the most convenient unit of wave-length—often spoken of as an "Angström Unit"—is the ten-millionth of a millimetre, or "tenth metre," and in this system, the visible spectrum ranges from about 3930 in the violet to 7600 in the red end of the spectrum. Thus, when it is stated that the wave-length of the D_3 line of helium is 5875·98 it is understood that it is that number of times a ten-millionth of a millimetre. It is not necessary, however, to directly determine a wave-length every time that an observation is made, and indeed this cannot be done when a prismatic spectroscope is employed, as is most frequently the case. Certain standard wave-lengths have been carefully measured, and it is usual to determine any required wave-length from these either by inspection or by interpolation. The most generally useful of these reference lines are those given in Rowland's "Tables of Solar Wave-lengths,"* which state with great accuracy the wave-lengths of many thousands of the dark lines which appear in the spectrum of the sun or daylight. In addition to the Tables, Prof. Rowland published a photographic map having a scale by which the wave-lengths can be read off directly with considerable accuracy. Rowland's map is said to be a "normal" one, for the reason that equal distances on the map correspond to equal differences of wave-length, which is not the case with prismatic spectra. A small portion of this map, corresponding in part with the photograph in Fig. 2, is reproduced in Fig. 3, and by comparing the two it will be seen that, although the photographs are not on the same scale, the wave-length of any required line, bright or dark, in Fig. 2 may be read off by the scale in Fig 3. For example, the three very strong lines of iron, forming a "triplet," near the left of Fig. 2 are clearly identical with the lines 4045·98, 4063·76, and 4071·91 in the solar map. Having a complete set of such maps, it is evidently an easy method of obtaining wave-lengths to photograph the spectrum of sunlight alongside that of the spectrum under examination. Sometimes, however, it is more convenient to use the spectrum of iron as a comparison, in which case reference might be made to the admirable wave-length map of this spectrum published by Messrs. Kayser

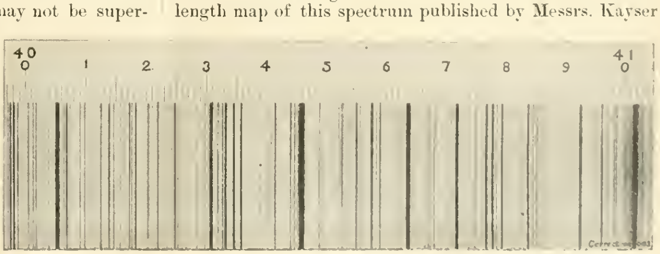


Fig. 3.—A portion of the Solar Spectrum, with Wave-length Scale. (Rowland.)

and Runge.†

When no comparison spectrum has been photographed in juxtaposition with that under investigation, and this is

* Published by the University of Chicago Press, 1896.

† *Abh. d. Akad. d. Wiss. zu Berlin*, 1888.

not always possible, the wave-lengths of the lines cannot be determined unless some of them are recognisable by their peculiar groupings, or otherwise. In this case the previous method may sometimes be used by superposing a solar spectrum photographed with the same instrument, or the wave-lengths may be determined by measurement of the photograph, basing the results on the lines which can be identified at sight. One mode of reduction may be illustrated by the use of Figs. 2 and 3. Suppose a finely-divided scale, say a rule divided to hundredths of an inch, to be laid on the bright-line spectrum in Fig. 2, the triplet of iron lines having already been identified in Fig. 3. Now read the positions of these three lines on the scale, and those of any other bright lines for which wave-lengths may be sought. Call the first three readings ς_1, ς_2, ς_3, and the corresponding wave-lengths λ_1, λ_2, λ_3, and solve the equation

$$\lambda = \lambda_0 + \frac{C}{\varsigma - \varsigma_0}$$

so as to determine λ_0, C, and ς_0, by first forming three equations in which λ and ς have corresponding values. Then, by using these constants, the wave-length corresponding to any other value of ς may be readily calculated. This formula for the calculation of wave-lengths from prismatic spectra was first suggested by the late Prof. Cornu, but has lately become more widely known and adopted through its re-introduction by Dr. Hartmann. It is the equation to a rectangular hyperbola with respect to axes parallel to the asymptotes, λ_0 and ς_0 being the co-ordinates of the intersection of the asymptotes, and is based on the supposition that this curve is at least very nearly identical with the curve of dispersion of a prism. The measurements of the photograph must, of course, be made with the greatest possible accuracy, for which purpose a stage micrometer is usually employed.

It is by methods such as these that the tables of wave-lengths of lines in terrestrial spectra, which are indispensable in attempts to identify the chemical constituents of the heavenly bodies, have been prepared. A very great service has been rendered to all engaged in spectroscopic work by Dr. Marshall Watts, who has brought together all the tables of wave-lengths which are scattered through the numerous scientific publications.*

In making use of such tables for the purpose of identifying lines met with in astrophysical investigations, special attention has to be given to the fact that in numerous cases the spectrum of a terrestrial substance varies very considerably with the conditions of experiment. The spectra of metals, for example, may be studied by volatilising them either in the oxyhydrogen flame, the electric arc or electric spark, and very often great differences in the spectra are noted. Magnesium furnishes an interesting example. As will be seen from Fig. 4, the arc spectrum

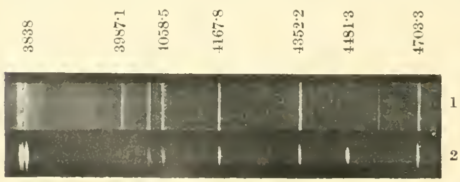


Fig. 4.—(1) Arc, (2) Spark, Spectra of Magnesium.

shows several strong lines, most of which also appear in the spark spectrum, but the latter shows, in addition, a strong line at wave-length 4481·3, a line belonging to the class called "enhanced lines" by Sir Norman Lockyer, since its intensity is increased in passing from the arc to the spark spectrum. On investigating the evidence as to magnesium in the solar spectrum, it is found that while the arc lines are there represented, the enhanced line is conspicuously absent. But if a similar comparison be made with the spectrum of Sirius, the line at 4481·3 is seen to be one of the strongest in the spectrum, while only the stronger of the arc lines are at all represented. It is quite clear then, that comparisons must not be limited to spectra produced under one set of experimental conditions. At times it is even necessary to go beyond our experimental resources to identify the lines met with in some of the stars, and by supposing continuity of change try to define what the spectrum of a substance would be when subjected to temperatures greater than any at the command of the laboratory worker. Thus, in the spectra of such stars as Rigel, there is a line which appears to agree perfectly in position with the above-mentioned spark line of magnesium, but as no other lines of magnesium are certainly present, it is necessary to suppose that the change, partially effected when the spark is substituted for the arc, is completed by the higher temperature of the star.

THE PATH OF THE MOON.—I.

By A. C. D. Crommelin.

The subject of the Moon's motion is a frequent source of perplexity to students of astronomy; they meet with statements in text-books which at first sight seem incompatible with one another, and are unable to reconcile them. The key to the solution of these difficulties lies in a perception of the fact that all our ideas of motion are essentially relative. If we picture to ourselves one solitary orb in boundless space, the statements that it is at rest or in motion are alike meaningless to us. We must have some point of reference to enable us to estimate any change in its position, and this at once introduces the conception of relative motion. Thus in discussing the motion of the Sun and its attendant planets through space we make the assumption that the group of stars around us has on the whole no tendency to move in one direction rather than another. We thus take the centre of mean position of the group of stars as a fixed point, and deduce the Sun's motion relatively to it. Hence different groups of stars may (and do) give different results for the solar motion, which simply implies that the one group is not at rest relatively to the other group. So in the case of the Moon our ideas of its path depend entirely on the point that we select as our point of reference; there are two points that naturally suggest themselves, viz., (1) the Earth, (2) the Sun. The apparent contradictions that were alluded to above arise from the fact that some of the statements refer to her geocentric, others to her heliocentric path.

Consider the case of a man walking round and round the mast of a ship, always keeping at the same distance from the mast. Then it is a perfectly legitimate statement that his path *on the deck* is a circle described with uniform speed. The words in italics are sufficient to qualify the statement and to indicate the origin from which the motion is reckoned.

On the other hand it is an equally legitimate statement that his path *on the sea* is an undulating or wave-like curve, described with variable speed, greatest when he is walking towards the bow, least when towards the stern.

We can get a good representation of the Moon's path

* "Index of Spectra," and Appendices. Published by Abel Heywood.

round the Sun by supposing the man to describe a circle of fourteen feet radius in fifty-nine seconds, while the ship is describing a circle of one mile radius about a lighthouse, or other fixed point in the sea, in twelve minutes ten seconds. Then the man's path *on the deck* will correspond to the Moon's path round the Earth, and his path *on the sea* to that round the Sun. Two seconds in the model correspond to one day in nature, while one mile corresponds to 93,000,000 miles.

We shall first discuss the nature of the resultant path on the assumption that the orbits of the Moon round the Earth and of the Earth round the Sun are circles in the

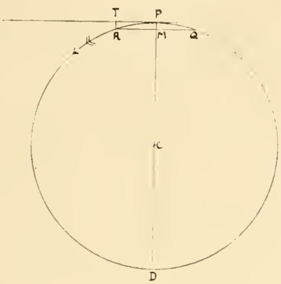


Fig. 1.—The Curvature of the Moon's Path

same plane described with uniform speed, and then pass on to a more accurate description of the nature of the Moon's path round the Earth, indicating a few of the many different ways in which it differs from uniform circular motion.

There is a whole class of curves, known as trochoids, described by points that move uniformly in a circle, whose centre moves uniformly in another circle in the same plane. As all the motions of rotation and revolution in the planetary system (excepting the satellites and probably the rotations of Uranus and Neptune) take place in the same direction, we shall only consider the case where the motion in the two circles is in the same direction. The resulting curves may be divided into the following five groups:—

(1) Those that are wholly concave to the centre of the larger circle.

(2) Those that are just straight at points corresponding to New Moon and concave elsewhere.

(3) Those that are partly concave and partly convex to the centre of the larger circle, the two regions being separated by "points of inflexion" where the curve is straight for a small space.

(4) Those where the points of inflexion coalesce in pairs and form cusps.

(5) Looped paths; these occur when the linear velocity of the point in the small circle exceeds that of its centre in the large circle.

Representatives of all these types, except the second, are to be found in the solar system.

Our Moon is the solitary example of the first type, the only case in which the Sun's attraction exceeds the attraction of the primary.

Phobos, Deimos, Ganymede, Callisto, Rhea, Titan, Hyperion, and Japetus, belong to type (3).

Europa and Dione at certain times conform exactly to type (4), and come to rest at New Moon. At other times they belong alternately to (3) or (5).

Io, Jupiter's Satellite V, Tethys, Enceladus, and Mimas belong to type (5).

The circumstances of Jupiter's satellites have been investigated by Mr. C. T. Whitmell in the *Journal* of the Leeds Astronomical Society, 1901, page 98. His diagram is reproduced by permission from that paper. The path of II. Europa, when it conforms exactly to type (4), is an epicycloid, or figure traced by a point on the rim of a wheel which rolls without slipping round the outside of a fixed wheel. When the fixed wheel is of infinite size, that is when it becomes a straight line, the epicycloid becomes a cycloid; and this is practically the case with Europa, since the path of Jupiter round the Sun is so enormous compared with the path of Europa round Jupiter. It only differs from curve II. on the diagram by having a cusp at N instead of the small loop.

It is not difficult to prove by elementary methods that the path of the Moon is everywhere concave to the Sun. This will clearly be the case if the fall of the Earth towards the Sun in a given time (say one hour) exceeds the fall of the Moon towards the Earth in the same time. The word "fall" here means the amount by which the body is bent away from the tangent to its path by the action of the attracting body in the centre. Thus, let QPRD be the Moon's circular path round the Earth, C, in the centre; P, the Moon's position at any selected time, and PT the tangent to her path at this time. QR are her positions one hour earlier and one hour later, the distance QP, PR being greatly exaggerated for clearness.

Then, clearly, if QR cuts PC in M, QM = RM, and the fall of the Moon in one hour = TR = PM.

Now by Euclid (III, 35) PM.MD = RM.MQ = RM^2. Now since the distance PR is such a small part of the circumference, RM is sensibly equal to PR, and MD is sensibly equal to PD. Hence we have PM.PD = PR^2,

$$\text{or PM} = \frac{PR^2}{PD}.$$

Now PD = 238,818 × 2 miles.

Also the circumference = PD × 3·1416 and the time taken to describe circumference = 27·3216 × 24 hours.

$$\text{Whence PR} = \frac{\text{circumference}}{27{\cdot}3216 \times 24} = \frac{PD \times 3{\cdot}1416}{27{\cdot}3216 \times 24}$$

$$\text{And PM} = PD \times \left\{ \frac{3{\cdot}1416}{27{\cdot}3216 \times 24} \right\}^2.$$

Working this out by logarithms we find that PM = 10·964 miles.

We can find the fall of the Earth towards the Sun in one hour by exactly similar reasoning.

PD is now equal to 92,885,400 × 2 miles; also instead of 27·3216 we now write 365·2564, being the number of days in the year.

Whence fall of Earth towards Sun in one hour

$$= 92{,}885{,}400 \times 2 \times \left\{ \frac{3{\cdot}1416}{365{\cdot}2564 \times 24} \right\}^2$$
$$= 23{\cdot}859 \text{ miles.}$$

We see from this that the fall of the Earth towards the Sun in one hour is considerably more than double that of the Moon towards the Earth. It follows that the resultant fall of the Moon is always towards the Sun, and consequently that her path is everywhere concave towards him. The concavity is, however, very much greater at Full Moon than at New; for in the first case the total fall towards the Sun in an hour is 23·859 + 10·964 miles = 34·823; in the second case it is 23·859 − 10·964 = 12·895, or little more than one-third of the first result.

The resultant velocity in miles per hour is

66576·08 + 2288·38 = 68864·46 at Full Moon.
66576·08 − 2288·38 = 64287·70 at New Moon.

We can now apply the formula found above, viz.—

$$PM = \frac{PR^2}{PD},$$

to find the diameter of the path of the Moon at Full, treated as part of a circle.

For, clearly, PM = resultant fall towards Sun in an hour = 34·823; also PR = resultant velocity per hour = 68864·46.

Whence PD = diameter of path $= \frac{(68864{\cdot}46)^2}{34{\cdot}823}$ miles.

And the radius of path is half this, or 68,091,700 miles.

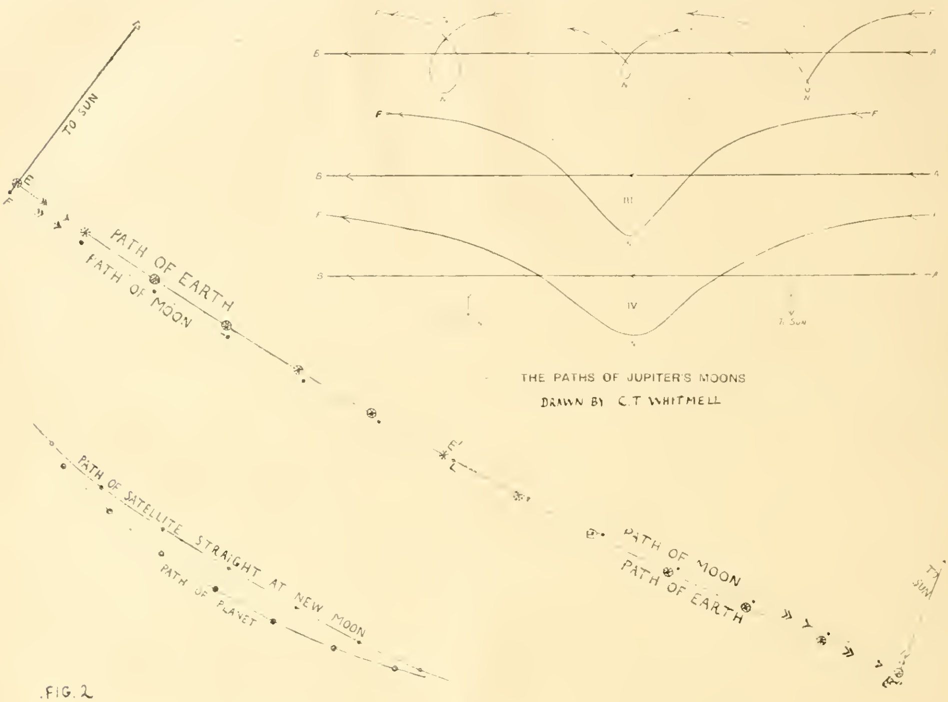
But the Sun at this distance makes the Earth fall 23·859 miles in an hour. And since the distances have been made the same, the falls are proportional to the masses of the attracting bodies.

Whence

$$\frac{\text{Mass of Sun}}{\text{Mass of Earth + Moon}} = \frac{23{\cdot}859}{10{\cdot}964} \times \left\{\frac{92{,}885{,}400}{238{,}818}\right\}^2$$

= 329,200.

The other result is to find at what distance from the Earth the Moon would have to be for her path round the Sun to be just straight (neither concave nor convex) at



THE PATHS OF JUPITER'S MOONS

DRAWN BY C. T. WHITMELL

FIG. 2.

In a similar manner we find that the radius of the path of the Moon at New, treated as part of a circle, is

$$\frac{(64287{\cdot}70)^2}{2 \times 12{\cdot}895} = 160{,}252{,}500 \text{ miles.}$$

It is fairly evident that these are the regions of maximum and minimum concavity, and that the radius of the path will gradually increase as we pass from Full Moon to New.

Before passing on from these figures, we shall indicate two other interesting results connected with them.

First we can obtain the mass of the Sun compared with the combined mass of the Earth and Moon. Suppose the Moon were moved to a distance from the Earth equal to the Sun's distance, then her fall towards the Earth in an hour would be

$$10{\cdot}964 \times \left\{\frac{238{,}818}{92{,}885{,}400}\right\}^2 \text{ miles,}$$

since it is inversely proportional to the square of the distance.

New Moon (type (2) given above).

This will clearly be the case if the fall of the Moon towards the Earth in one hour is exactly equal to the fall of the Earth towards the Sun; *i.e.*, we must make the former fall equal to 23·859 miles. But this fall varies inversely as the square of the distance.

$$\text{Hence } \left\{\frac{\text{Required distance}}{238{,}818}\right\}^2 = \frac{10{\cdot}964}{23{\cdot}859}.$$

Whence the required distance = 161,889 miles.

This distance is likewise the radius of the sphere over which the Earth holds supreme sway; at its boundary the attractions of the Earth and Sun are equal, while within it the Earth's attraction exceeds that of any other body. All satellites, except our Moon, lie within the sphere over which their Primary rules supreme; this is the reason why their paths in all cases belong to types (3), (4), or (5) given above.

The reader acquainted with the geometry of curves of

higher orders will see that the New Moon point on the curve of type (2) is a point not of inflexion but of undulation, since the tangent here does not cross the curve at the point, as the tangent at a point of inflexion does. The tangent here coincides with the curve in four points, not in three, so that the departure of the curve from a straight line in the neighbourhood of the point is quite insensible. The path of an imaginary satellite conforming to this type is shown on the diagram.

We shall now indicate the manner in which the path of the Moon, or those of the other satellites, may readily be drawn. The scale should be taken as large as possible, and it is impossible to give the entire curve in the case of the Moon on a diagram of reasonable size; it is, however, sufficient to trace the curve from Full to New, the rest of it being composed of simple repetitions of this portion turned alternately backwards and forwards.

For a representation of the Moon's path from Full to New in the pages of KNOWLEDGE, we are restricted to a scale of 7 inches for 15° of the Earth's orbit. This gives us as our maximum available scale one-fourteenth inch for

FIG. 3.—The Variation Oval.
○ = Mean Moon. ● = Moon affected by variation.

the Moon's distance from the Earth, and 28·4 inches for the Earth's distance from the Sun. We therefore draw an arc of a circle with this radius, and take a point E on the arc as the Earth's position at Full Moon. The Moon is then at F on the radius produced. The time from Full to New Moon is half of 29·5306 days, or 14·7653 days, in which time the Earth moves through 14° 33⅙′. Her perpendicular distance from the initial radius is then 7·12 inches, which determines E″ her position at New Moon. The Moon is then at N on the radius through E″. The Moon's path at Full and New Moon approximates to small circular arcs with radii 20·8 and 48·9 inches respectively, these corresponding to the radii found above. Further, at last Quarter we place the Moon at L on the Earth's orbit, one-fourteenth inch ahead of E′, the middle point of the arc EE″. For convenience of subdivision the arc EE″ is divided into 12 portions, each described in about 1¼ days. The dots representing the Moon are placed at a constant distance from those representing the Earth, and revolving round it with uniform angular velocity. The dotted curve representing the Moon's motion round the Sun can then be drawn, and it will be seen that it is concave to the Sun at N, though much more nearly straight here than at F.

Letter.

[The Editors do not hold themselves responsible for the opinions or statements of correspondents.]

THE SOLAR DISTURBANCES OF SEPTEMBER, OCTOBER AND NOVEMBER, 1902.

TO THE EDITORS OF KNOWLEDGE.

SIRS,—From a study of the great solar outburst of last September and the subsequent disturbances of October and November, I have been led to observe certain curious coincidences—to use no stronger term—in regard to the position of some of these disturbances and the order of their appearance on the solar disc. Thus the September outburst, which consisted of a chain of disturbances lying practically along a meridian, and extending from a high south latitude into the equatorial zone of the northern hemisphere, was followed early in October by a group of spots in the *northern* hemisphere and at a distance in longitude of about 180°. Now allowing an apparent or synodic rotation period of 26½ days to the latter group and 27 days to the most important portion of the former, situated about south latitude 24°, we find that October and November gave us repetitions of the above phenomena in a portion of the disturbed area, and that each recrudescence *appeared* to affect a portion of the opposite hemisphere situated at the extremity of a diameter. The same rule also held good in regard to a group of faculæ independent of the above, and which, appearing toward the end of October in the southern hemisphere, had its *vis-à-vis* in November in the northern hemisphere.

If these facts be something more than mere coincidences, do they not suggest the conclusion that in the displays of the last three months we were viewing some of the effects of eruptions deeply seated and powerful enough to shake the whole body of the sun, and to cause great waves to converge at their antipodes, and to excite other eruptions in turn?

Moneybroom, Lisburn, JOHN M. HARG.
16th December, 1902.

NOTES.

ASTRONOMICAL.—In his work on the nebulæ, Sir William Herschel recorded the positions of fifty-two supposed extensive regions of diffused nebulosity. Recognising the great importance of these in considerations relating to the structure of the universe, Dr. Isaac Roberts has made a careful photographic investigation of the regions in question, with the remarkable result that in only four of them has any nebulosity been found, although the photographs show stars as faint as 17th magnitude. One of these four, branching out from ζ Orionis, is of peculiar interest.

The interesting suggestion made by Sir David Gill a few months ago, to the effect that the brighter stars, as a whole, appear to have a motion of rotation with respect to the fainter stars, has been tested at Oxford by Prof. Turner. A relative motion similar to that described by Sir David Gill, and equal in magnitude, was indicated by

a comparison of photographs taken in 1892 and 1902, but the motion was in a contrary direction. It is not impossible, however, to reconcile these seemingly opposed results.—A. F.

BOTANICAL.—The last volume of the *Annales du Jardin Botanique de Buitenzorg* contains a paper by Prof. O. Penzig on the flora of Krakatoa. This, and a paper published by Dr. Treub in the seventh volume of the *Annales*, are especially interesting as throwing some light on the question of the origin of insular floras. Krakatoa lost all its vegetation in the terrible volcanic eruption of August, 1883, which covered the island to a depth varying from one to sixty metres with a bed of red-hot ashes and pumice-stone. Its appearance afterwards, according to Dr. Treub, was that of a mountain isolated in the sea, rising with almost perpendicular sides to a height of 2500 feet. The island, which is 21 miles from Java and 20 from Sumatra, was visited by Dr. Treub in 1886. He found it uninhabited, and not easily accessible. On the narrow beach he found fruits or seeds of 7 species of phanerogams, and young plants of 9 species, all the latter, excepting one grass (*Gymnothrix elegans*), being the usual littoral plants of tropical islands. In the interior the vegetation was quite different—ferns, both in the number of species and individuals, predominating. Dr. Treub concluded that ferns in such a flora precede and prepare the soil for a phanerogamic vegetation. Their minute spores would be brought long distances by the wind, but it was remarkable that these would germinate and develop into plants on the intensely arid soil of Krakatoa. A close examination of the ashes and pumice-stone, however, revealed the presence almost everywhere of Algæ (Cyanophyceæ), coating the soil with a thin gelatinous layer in which the fern-spores would find a suitable place for germination. Besides lower cryptogams, Dr. Treub found, in 1886, 15 phanerogams and 11 ferns. Prof. Penzig's paper records a visit to the island in 1897, made by himself, Dr. Treub, and other botanists. The flora consisted at that time of 62 species (50 phanerogams and 12 vascular cryptogams) belonging to 24 orders. The ferns still predominated in the interior, and several species of tall grasses formed a striking feature of the vegetation. Seeds or fruits of 30 species were found on the beach, and here and there seedling plants, showing that the seeds were capable of germination. Of the 53 phanerogams. Prof. Penzig estimates that 17 were introduced by the agency of the wind, 32 by water, and 4 by birds.—S. A. S.

ZOOLOGICAL.—In a paper on the larvæ of the various species of eel, published in the *Transactions* of the American Philosophical Society, Mr. C. H. Eigenmann discusses the question whether these fishes ever breed in fresh water. Till eggs are actually taken in lakes the question must remain *sub judice*, for, as the author very pertinently remarks, the fact that eels are found in land-locked basins cannot be regarded as an absolute proof that they breed there, although it is difficult to see how they can continue to exist in such situations without doing so.

A small fish from the rivers of West Africa, measuring about three inches in length, and provided with elongated pectoral fins, is in the habit of taking aërial flights after the fashion of the true flying fish and flying gurnards. This fish (*Pantodon buchholzi*) is the only freshwater species known to possess powers of this nature. Although allied to the *Osteoglossidæ*, it is regarded as the representative of a special family—the *Pantodontidæ*. A reproduction of a photograph of this remarkable fish has been recently published by Mr. G. A. Boulenger in *The Field*. In the same journal that gentleman describes an unusually large kind of tadpole from South Africa, measuring five inches in length. Here we may take the opportunity of correcting an error in our December "Notes" column, where the original description of the marine representative of the genus *Galaxias* was accredited to Mr. Boulenger instead of to Captain Hutton. The specimen on which the determination is based was found in the mouth of a larger fish taken off Auckland.

An important memoir on the true seals of the North Pacific and Bering Sea has been recently published by Dr. J. A. Allen in the *Bulletin* of the American Museum. Perhaps the most generally interesting portion of this communication relates to the difference between the dentition of the male and female of the common seal. In the latter sex the teeth are much smaller than those of the male, and are inserted more obliquely in the jaw; they also differ by the reduction in the size and number of the accessory cusps, which are almost invariably absent on the inner side. The author recognises a considerable number of species of Pacific seals, some of which might, however, be regarded by other naturalists rather in the light of local races.

In a communication recently published in the *Revista* of the La Plata Museum, Dr. R Lehmann-Nitsche doubts the possibility of the survival in South America of the Patagonian ground-sloth, of which the remains were found in such fresh condition in the well-known cavern at Ultima Esperanza. He believes the reports of its existence at the present day to be based on other animals—notably the otter. In the same journal, Dr. S. Roth describes the remains of other mammals found in association with those of the ground-sloth. Among the most interesting of these is the skull of a large jaguar (*Felis listai*), half as big again as that of the living species. The author also describes and figures the foot-bones of four species of extinct American horses, one belonging to the genus *Equus*, a second to *Hippidium*, and the other two to *Onohippidium*. The latter are characterized by their extreme shortness; and if, as appears to be the case, the lateral toes were wanting, *Onohippidium* seems to have become monodactyle independently of the true horses, since its skull is quite different from those of the latter. This is a matter of extreme interest, to which South American palæontologists might well devote special attention.

Hitherto only a single form of the African aard-wolf (*Proteles cristatus*) has been recognised by naturalists. In a recent issue of *Novitates Zoologicæ* the Hon. Walter Rothschild has shown that three local races exist, namely, the typical Cape form, the Angola form, distinguished by its rufous colour and fewer stripes, and the Somali race, characterised by its creamy-white ground-colour and possibly by its small size.

Since the year 1894, Mr. Rothschild has published from time to time, in *Novitates Zoologicæ*, a series of most valuable and interesting notes on giant land-tortoises, mainly based on the specimens in his own collection at Tring and in the Zoological Gardens. One of the most important determinations made by him is the fact that the celebrated Port Lewis tortoise, commonly known as Marion's tortoise, originally came from the Seychelles, and that it typifies a distinct species, *Testudo sumeirei*, characterised, among other features, by the absence of a nuchal shield. During the past year three papers on giant tortoises—one by Dr. A. Günther, and two by Mr. Rothschild—have appeared in the journal already named. In the first of these Dr. Günther describes the shell of a tortoise from Charles Island, in the Galapagos group, which had been made the type of a new species (*T.*

galapagoensis) by the late Dr. G. Baur. It is a member of the so-called saddle-backed group, of which four species are now known, namely, *T. galapagoensis* from Charles Island, *T. ephippium* from Duncan Island, *T. becki* from North Albemarle, and *T. abingdoni* from Abingdon. In one of his two papers Mr. Rothschild describes, under the name of *T. wallacei*, a shell probably from Chatham Island, Galapagos group, which was formerly in Bullock's Museum. The author believes it to be the only known representative of a once common species. We hope shortly to publish an article on giant tortoises.

A correspondent "Adolescens," writes to us as follows:—"I have read that some kinds of bees, flies, and water-fleas, are produced from eggs that have never been fertilised by the male. Is this true? I shall be obliged if you will kindly answer this question in the 'Notes and Queries' of your next issue, and tell me what animals are produced (if any) by parthenogenesis." We can perhaps answer this best by quoting from Dr. D. Sharp, who writes as follows in the first of the two volumes on Insects in the *Cambridge Natural History*:—

"There are undoubted cases in insects of the occurrence of parthenogenesis, that is, the production of young without concurrence of a male. This phenomenon is usually limited to a small number of generations, as in the case of the *Aphididæ* (plant-lice), or even to a single generation, as occurs in the alternation of generations of many *Cynipodæ* (gall-flies), a parthenogenetic alternating with a sexual generation. There are, however, a few cases of insects of which no male is known (in *Tenthredinidæ, Cynipidæ, Coccidæ*), and these must be looked upon as perpetually parthenogenetic. It is a curious fact that the result of parthenogenesis in some species is the production of only one sex, which in some insects is female, in others male. . . . In some forms of parthenogenesis, the young are produced alive instead of in the form of eggs." It may be added that at least some drone bees are produced by parthenogenesis.

Notices of Books.

"A Naturalist in Indian Seas." By A. Alcock, M.B., LL.D., F.R.S. (Murray. 1902.) 18s.—The author tells us in his preface that this volume "is compiled from the records of the Royal Indian Survey Ship 'Investigator'"; but the compilation has been made with such rare skill and judgment that the past lives again in his pages, and the distant is brought near. Hence, we venture to think this book will come to many as a revelation, not only of the methods of marine surveying and zoological investigation, but also of a world of life, kaleidoscopic in its changes, and romantic in its facts. He has conjured up a panorama of the most alluring description: Indian temples and tropical islands, coral reefs and peaceful lagoons, raging seas, and the mysteries of their uttermost depths, are each in turn presented, and their several inhabitants pointed out and described, in such a way that we see them, not as so many ethnological and zoological examples, but as living creatures, leading strenuous lives hitherto undreamt of by the stay-at-home reader—unless he be also a zoologist. If none of the facts in this book are absolutely new it is because they have already been published by the author, and others working out the materials supplied by him, in the pages of the *Proceedings* of various learned societies. Here, however, they were accessible only to the professed zoologist; in their present form, carefully selected and reset, they will be welcomed by the lover of travel and natural history the world over. Of the many remarkable facts recorded in this book not the least interesting are those concerning certain viviparous rays, the young of which are nourished by a secretion, formed by vascular filaments of the oviduct, closely analogous to milk. These filaments, in a small sting-ray (*Trygon bleekeri*) were found "dripping with milk." This is conveyed into the body of the embryo, not through the mouth but directly into the throat through the modified first pair of gill-clefts or spiracles; the milk-secreting filaments passing from the wall of the oviduct into these apertures. The method of extracting the milk by sucking, which prevails among the higher mammals, is here of course impossible, consequently, it is pumped into the gullet by the contraction of muscular fibres investing the filaments in question, a method which recalls the squirting process of feeding which obtains among the marsupials. The absorption of the yolk-sac by the short-tailed bat-ray (*Pteroplatea micrura*) is another extremely interesting instance, affording an instructive illustration of the substitution of organs. This yolk-sac "contained no blood-vessels for absorbing the yolk such as are generally found in all yolk-sacs"—but instead this work was done by the external branchial filaments—the long and delicate vascular processes which later form the external gills, and which later still disappear and are replaced by the internal gills of the adult. Of the weird and wonderful ways of the deep-sea fishes and other creatures, and how they contrive to make life possible, if not worth living, in those regions of eternal night and unbroken silence, Dr. Alcock has much to say, and not a little that is new. Dr. Alcock is inclined to doubt the authenticity of the accounts of the tree-climbing powers of the celebrated robber-crab (*Birgus latro*) which he found in South Sentinel Island. That these stories are probably true, however, we may infer from the accounts published not long since by Dr. Andrews, of the British Museum. On Christmas Island he found these crabs climbing the sago-palms when the fruit was ripe in order to feed thereon. Apparently, some successfully made the ascent, whilst others waited below to feast upon the fruit which had either fallen naturally or had been detached by their fellows up aloft. Musical crabs, fighting crabs wielding ponderous war-clubs, hermit crabs which live in bamboo-stalks, and numerous other remarkable crustacea are vividly described in these pages, together with a host of other creatures, the mere enumeration of which would unduly prolong this notice. Reluctantly we bring this short account to a close, with the conviction that the book will take first rank among those of its kind—and these are many. It is a delightful volume, well printed, well illustrated, handsomely bound, and without a dull page.

"Biological Laboratory Methods." By P. H. Mell, Ph.D., Director of Alabama Experiment Station, &c. (Macmillan & Co.)—This book combines general instructions for the use of the microscope and its accessory apparatus, directions for imbedding, staining and generally preparing micro-sections, with separate chapters on photo-micrographic apparatus and methods, the study of bacteriology, and the polarisation of light, and concludes with useful formulæ and tables, together with suggestions for the arrangement of the laboratory and its furniture. The hints generally for conducting laboratory work, although suffering from the defect of superficiality, which must of necessity occur where so large an area is covered in a small volume, are concise and in many respects valuable.

The aim of the writer, set forth in the "Introduction," to "deal with facts in a perfectly scientific, accurate manner," is unfortunately unrealised in many of the chapters, and especially is this so when he is dealing with microscopical and general optical principles. The writer assumes, for instance, that a Coddington Magnifier is an Aplanatic Triplet, and further states that the Wollaston Doublet increases the distance between the lens and the object, whereas the reverse is actually the case. The descriptions of spherical and chromatic aberration are both vague and confusing. He states that the method of correcting spherical aberration is to so grind the lens that its curvature at the edge is less than at the centre, presumably referring to a system of "figuring" which is never applied to microscopic objectives; while an achromatic objective is stated to be "so constructed that the coloured rays decomposed out of the white light by the first lens are recomposed by the next lens into white light."

The instructions for the working of the Abbé Condenser, evidently the only condenser known to the author, are vague in description and wrong in practice, the worker being recommended to "stop down" and to control the light by racking it out of focus—a method which was in vogue twenty years ago, when the necessity of focussing the condenser, and the advantages generally derivable from its use, were little appreciated. He further states that "dark ground illumination is obtained by adapting a diaphragm with the opening in the shape of a ring and the centre oblique."

In treating of the influence of the cover-glass, special emphasis is laid on the effect produced by the variation of thickness of cover when oil-immersion lenses are used. As a matter of fact, these lenses are theoretically least susceptible to this influence, on account of the homogeneity of the medium which forms contact between the front lens and the cover-glass, and herein lies one of the great advantages of oil-immersion lenses.

The description of the polarisation of light is similarly misleading, and the statement is made that the dark field is obtained when the two Nicol's prisms "are *almost* at right angles."

Space does not allow of further extracts, but the book generally leads to the conclusion that the wide range of knowledge which is so essential in those who give directions and advice to others is lacking in the experience of the writer, and that his information on optical subjects has been gleaned from an acquaintance with a very limited amount of apparatus and knowledge of its general principles. There is here material for a really practical and useful book, but the information it gives should be reliable to justify its existence.

"Publications of West Hendon House Observatory, Sunderland." No. II. By T. W. Backhouse, F.R.A.S.—Five subjects are included in this most valuable work, which, it should be observed, is not a finished treatise on any one of the sections treated, but a mine from which others may dig the ore that they will mould to their own uses. The sections are:—Part II. of The Structure of the Sidereal Universe; Comets Bernard (1886) and Holmes (1892); The Zodiacal Light; The Aurora Borealis; and Variable and Suspected Variable Stars. In the first section Mr. Backhouse studies the drawings by Easton and Boeddicker, and the photographs by Dr. Isaac Roberts, Prof. Barnard, Prof. Max Wolf, Mrs. Maunder and others published in Knowledge or elsewhere, and compares the results of various markings or orderings of stars on these with the study of the same regions which he has made visually with a $4\frac{1}{4}$-inch Cooke refractor. His conclusions are most definite in the regions of the Milky Way, whose effect he judges to be built up for the naked eye by aggregations of stars below the 10th in magnitude. In other regions of the sky he confirms the existence of many streams of stars and rifts, but can come to no definite conclusion as to whether radial series of streams and rifts do actually exist as such or whether they are simple effects due to the accidental crossing of two or more series of parallel streams. In this connection we think some light might be shown by a well-marked feature of many of Dr. Roberts' photographs, namely, the spiral arrangement of curved lines of stars (not nebular spirals), which might well give in some cases the effect of radiating spokes of stars. We do not find that Mr. Backhouse refers to or has studied this spiral formation.

His observations of the place of the Counterglow extend from 1871 to 1895, but he says that, looking at the whole of these observations, it seems impossible to arrive at any conclusion as to the inclination of the Zodiacal Light to the Ecliptic, there being but a very slight preponderance in favour of an ascending node about longitude 10°. The observation of auroræ have become increasingly difficult with the increase in size and the better lighting of the town. His observations tend to confirm slightly the contention of Dr. Veeder, that when an aurora is seen there is a tendency for the phenomenon to recur when the same part of the sun's disc is again presented to the earth; but he thinks that little weight can be given to it as this so nearly coincides with a lunation, which itself gives a false periodicity in the observation of auroræ.

Each section is illustrated by several very fine plates.

"Elementary Photo-Micrography." By W. Bagshaw. (London: Iliffe & Sons, Limited. 1902.) Illustrated. 1s. net.—This book, while recognising the advantages derivable from the use of the best means for the work, indicates in a simple yet direct manner how photo-micrography may be done with simple instruments and contrivances, and the use of common sense. Work in such circumstances necessarily has its limitations, but as there is a tendency in the majority of books on photo-micrography to treat the subject as though every worker had the purse of "Fortunatus," it may induce those whose resources are limited to attempt this fascinating work; and not to such alone, but to photo-micrographers generally, this little book will be found to contain many useful hints, based on sound, practical knowledge.

"Practical Photo-Micrography." By Andrew Pringle. (Iliffe & Sons.)—This is the third edition of a work which has become a standard on the particular subject with which it deals, and the writer is one who so graphically describes his own practical methods of working as to enable the reader to grasp the directions given and realise the results described. The present issue, which is printed on art paper, and has numerous appropriate illustrations, has been brought up to date in every respect, and the consideration given to the subject of dry plates corrected for colour will be found of special interest. Throughout the book there is no tendency to stint apparatus; it is practically a disquisition on how to do the best work with the best apparatus, although many suggestions to the worker of modest means are given. Photo-micrographers generally will find this new edition of Mr. Pringle's book a valuable help in their work.

"On an Inversion of Ideas as to the Structure of the Universe," By Prof. Osborne Reynolds, F.R.S. Pp. 44. Illustrated. (Cambridge: University Press. 1902.) 1s. 6d.—Whatever may be the ultimate decision as to the validity of Prof. Reynolds's explanation of the nature of the æther and matter, his contribution to the study of this subject must be regarded as of the highest importance. In the little volume under notice, containing the Rede Lecture delivered at Cambridge in June last, we have merely the outlines of a bold theory, the details of which will be published later. The experiments described to illustrate the theory are so remarkable that they alone make the book a desirable possession for teachers and students of physics. Briefly, the view put forward by Prof. Reynolds, and held to be sufficient to provide a mechanical explanation of the phenomena and effects of light and gravitation, is that the æther or medium existing throughout our universe consists of inconceivably small grains. Matter really represents a deficiency of these grains, causing a strain in the medium and thus accounting for the law of gravitation. The grains have diameters equal to the seven hundred thousand millionth part of the wave-length of violet light, and their mean path is equal to the four hundred thousand millionth part of the diameter; their velocity is about one and one-third feet per second. The mean density of this universal medium is stated to be ten thousand times greater than that of water, or four hundred and eighty times greater than that of the densest matter on the earth. The mean pressure is nearly seven hundred and fifty thousand tons on the square inch, being more than three thousand times greater than the strongest material can sustain. From the assumed co-efficient of transverse elasticity of this hypothetical medium the rate of the transverse wave is found to be that of light, while that of longitudinal waves is two and four-tenths greater. It is impossible here to discuss the evidence upon which Prof. Reynolds bases these conclusions, but we do not hesitate to say that, both as regards foundation and superstructure the theory represents an inspiring, if only imaginative, view of the constitution of the physical universe.

"The Dominion of the Air; the Story of Aërial Navigation." By the Rev. J. M. Bacon. Pp. 352. Illustrated. (Cassell.) 6s.—Mr. Bacon has produced a very interesting and valuable book, in which he describes not only the popular aspects of aëronautics from mediæval times to the present day, but also gives attention to the scientific results which have been obtained. It is a great convenience to have in a compact form a trustworthy account of what has been accomplished in recent years in ballooning and other means of aërial navigation, and to trace the development of the airships from the imaginative structures of Roger Bacon and Father Lana to dirigible balloons like that of Santos Dumont. Mr. Bacon has himself taken no slight part in what may be termed the renaissance of ballooning, and his own observations and conclusions contribute to make his book a noteworthy one. It is usually stated that Lunardi was the first successful aëronaut on British soil, but Mr. Bacon shows that the credit belongs to a Mr. Tytler, who made an ascent on August 27th, 1784, more than a month before Lunardi's aërial voyage from London to Ware. The duration of Lunardi's trip was 2 hours 15 minutes, which is a very good record considering that no free balloon can even now remain aloft for much more than thirty-six hours. There is little prospect of great progress in ballooning as a means of aërial locomotion. By carrying liquefied gas it might be possible to

provide a means of keeping a balloon inflated for six weeks, but even then the balloon would be at the mercy of the wind. Mr. Bacon devotes an interesting chapter to Andrée and his voyages, and in connection with it suggests that in any future attempt to reach the Pole by balloon, wireless telegraphy should be used to maintain communication with the base. Many observations attract attention in reading the book. Glaisher and Coxwell's noteworthy ascents are described and the results summarised. We also find accounts of the work of the French aëronauts, experiments with aëroplanes, and modern airships of various kinds. The book is, indeed, a fair and sufficiently full record of the attempts which have been made to navigate the air; and it will be read with interest both on account of the element of adventure in it and for the information it contains.

"THE COMMON SPIDERS OF THE UNITED STATES." By James H. Emerton. Pp. 225. Illustrated. (Ginn & Co. 1902.) 6s. 6d. net.—Though spiders are not regarded by many people as interesting creatures to study, yet the webs of web-spinning species are sufficient to show to everyone that spiders will repay all the attention given to them. In addition to the family of spiders which make webs to catch insects, there is the family of hunting spiders, which pounce upon their prey from various hiding-places. Mr. Emerton gives a description of the spiders of the United States, with a figure of each species placed as near as possible to the description. The book thus provides a means of identifying spiders, and the numerous beautiful reproductions of photographs of the webs and egg cocoons of various species will be of further assistance in this connection. In an introduction the author describes the parts and characteristics of spiders, and gives useful guidance to the naturalist. It would have added to the interest of general readers if a short account could have been given of instinctive habits and intelligent actions of spiders, such as anyone can easily see, but the book does not on this account lose any of the value it possesses as a guide for the use of students.

"A TEXT-BOOK OF PHYSICS." By Prof. J. H. Poynting, F.R.S., and Prof. J. M. Thomson, F.R.S. "PROPERTIES OF MATTER." Pp. 228. Illustrated. (Griffin & Co. 1902.) 10s. 6d.—It is scarcely necessary to say that students of physics cannot fail to derive benefit from reading this book. The authors are leaders in the field of physical inquiry, and their work reflects faithfully the prominent characteristics of methods, and significance of results, in the ground covered. The volume deals with the fundamental properties of matter which must be understood before much progress can be made in the study of physics. A similar volume on the science of Sound has already been published, and others are to follow dealing with Heat, Light, Magnetism, and Electricity, so that the complete series will provide students with a treatise in which all the main departments of physics will be surveyed. In the present volume, the authors deal with weight, mass, gravitation, and those properties of matter which relate chiefly to change of form, such as elasticity, fluid viscosity, surface tension, diffusion, and solution. The book is characterised by thoroughness, and by the attention given to recent results of permanent value. Traditional ideas as to the order and nature of the subjects to be dealt with in commencing the study of physics—exemplified in the books of Ganot and Deschanel—have not been permitted to control the character of the contents. Early experiments and results have only been used when necessary to illustrate particular points, and discrimination has been exercised in the selection of material from the numerous researches of recent years. The treatment of gravitation is most instructive, and the same may be said of capillarity. Here and there, students not well equipped with mathematical knowledge will find a little difficulty in following the argument, but most of the book is well within the range of every serious student of physics. But though the authors have been successful in their treatment of their subjects, they can scarcely be congratulated upon many of the figures, which are frequently too large and often spoil the appearance of the page. We refer to such illustrations as Figs. 23, 73, 74, 81, 89, 90, 91, 92, and 134. Figs. 27 and 28 are too indistinct to be of any value, and ought to have been omitted if they cannot be made to show up better than they do upon the paper used. Attention to minor matters such as these would have added to the attractiveness of the book.

"THE HEAVENS AT A GLANCE, 1903."—We are glad to see the seventh annual issue of Mr. Arthur Mee's useful little astronomical calendar. He has improved it, in our opinion, by printing it on a smaller card, and on both sides of the card, and by the introduction of a couple of star charts. The smaller map represents the northern heavens as seen from Great Britain, and the larger one the southern. There is also a little key-map to the principal lunar formations.

BOOKS RECEIVED.

Problems in Astrophysics. By Agnes M. Clerke. (A. & C. Black.) Illustrated. 20s. net.

Annual Report of the Smithsonian Institution 1901. (Washington: Government Printing Office.)

History of Hindu Chemistry. By Praphulla Chandra Ray, D.SC. (Williams & Norgate.) 12s. 6d. net.

Mont Pelée and the Tragedy of Martinique. By Angelo Heilprin. (Lippincott.) Illustrated. 15s. net.

Modern Microscopy. By M. I. Cross and Martin J. Cole. (Baillière, Tindall & Cox.) Illustrated. 4s. net.

Theoretical Organic Chemistry. By Julius B. Cohen, PH.D. (Macmillan.) Illustrated. 6s.

Preservation of Fishing Nets. By J. T. Cunningham, M.A. (Black.) 1s. net.

Volcanic Studies. By Tempest Anderson, M.D., B.SC., &c. (Murray.) 21s. net.

Simple Experiments in Magnetism and Electricity. By A. E. Munby, M.A., F.C.S. (Macmillan.) 1s. 6d.

Lope de Vega and the Spanish Drama. By James Fitzmaurice-Kelly. (Gowans & Gray.) 1s. net.

Photo Era. Christmas, 1902. 15 cents.

Astronomical Observatory of Harvard College, Annual Report, 1902. By Edward C. Pickering. (Cambridge, Mass.: The University.)

Thornton-Pickard Abridged Catalogue.

Sanitation, Personal and Public. By J. P. Sandlands, M.A., T.C.D. (Elliot Stock.) 2s. 6d. net.

Open-Air Studies in Geology. By Grenville A. J. Cole, M.R.I.A., F.G.S. (Chas. Griffin.) Illustrated. 8s. 6d.

Hazell's Annual for 1903.

British Ornithological Notes.

Conducted by HARRY F. WITHERBY, F.Z.S., M.B.O.U.

On the Occurrence of Phylloscopus viridanus, Blyth, and other interesting Birds at Scottish Light Stations. By Wm. Eagle Clarke. (*Annals of Scott. Nat. Hist.*, January, 1903, pp. 22–26.)—Mr. Clarke here gives details of the capture at Scottish lighthouses of a Greenish Willow-Warbler (*see* KNOWLEDGE, December, 1902, p. 278), Lesser Whitethroat, Black-tailed Godwit, and Sooty Shearwater.

The Sooty Shearwater (Puffinus griseus (Gmel)*) in the Firth of Forth.* By William Evans, F.R.S.E. (*Annals of Scott. Nat. Hist.*, January, 1903, pp. 26–28.)—Mr. Evans is strongly disposed, from personal observation, to consider the Sooty Shearwater a regular, or all but regular, autumn visitant to the Firth of Forth. The only known breeding places of this bird are in the New Zealand group of islands, and Mr. Evans' conclusion of its regular appearance off our coasts points to a regular migration of an almost incredible extent.

Glossy Ibis in Roxburghshire and in Islay. (*Annals of Scott. Nat. Hist.*, pp. 49, 50.)—Mr. Archibald Steel records that an immature specimen of this bird was shot on the Tweed on November 17th last, while Mr. Charles Kirk records that a similar specimen was shot on Islay on October 30th last. The bird has seldom been recorded from Scotland.

Nesting of the Hawfinch in Breconshire. (*Zoologist*, December, 1902, p. 455.)—It has been noted for some years that the Hawfinch is increasing its range westward. In 1890 it was discovered to be breeding in Breconshire, and Mr. E. A. Swainson considers that it is increasing in that county. Last year he found a nest in the west of Breconshire, a point which he considers as possibly the most westerly at which the Hawfinch has been known to breed.

Melanistic Variety of the Water Rail. (*Zoologist*, December, 1902, p. 467.)—Messrs. Williams & Son, of Dublin, note that a Water Rail, shot near Dublin on November 13th, was entirely black, with the exception of the barred feathers on the sides and the under tail coverts, which were dull white. The beak and feet were also black, and the eyes dark brown.

Bullfinch in Shetland. (*Zoologist*, December, 1902, p. 468.)—Mr. T. Edmonston Saxby records that he obtained a female Bullfinch in Shetland on November 8th. This is, it appears, only the second authenticated instance of this bird's appearance in Shetland.

Winter Nesting of Birds.—At the December meeting of the British Ornithologists' Club, Mr. T. Digby Pigott announced, on behalf of Lord Moreton, that during the week ending November 22nd last a Thrush had hatched out a young one, and a Starling and a Wren had laid eggs at Sarsden, in Oxfordshire. He also reported on the authority of Mr. R. Norton, of Downs House, Yalding, that in the same month there were young Martins in a nest in Kent.

Variety of the Woodcock.—At the same meeting, Mr. W. B. Tegetmeier exhibited an interesting and striking variety of the Woodcock with the ground-colour of a lilac-grey, and the chestnut vermiculations of a bright tint. The ends of the primaries were all white, with the usual black markings replaced by lilac-brown. The under parts were creamy-buff, faintly barred with pale greyish-brown. The throat white; the bill rather paler than usual, but the iris of the normal colour. The bird was a female, and was procured in the Galtee Mountains, Tipperary.

Dotterels in Merionethshire (Ibis, January, 1903, p. 133).—Mr. O. V. Aplin writes to the *Ibis* that he saw Dotterels on a mountain in Merionethshire in May, 1902, as he did in 1901. This bird occurs only occasionally in Wales, but since Mr. Aplin has seen the bird for two years in succession in the same place, it seems that some at all events are regular visitors to the Cambrian mountains. It is also just possible that they remain to breed there; but Mr. Aplin remarks that the birds could not be found in June.

The British Geese (Anser paludosus (Strickl.) *and Anser neglectus).*—Reference was made in the November (1902) issue of Knowledge to some notes on the British Geese by Mr. Coburn and by Mr. Frohawk. Mr. Coburn now calls attention *(Zoologist*, December, 1902, pp. 441-448) to a bird which he procured at St. Abb's Head, Scotland, on February 25th, 1896. Mr. Coburn somewhat confidently concludes that this bird is the same as that described by Strickland in 1858 as *Anser paludosus*, which Strickland presumed was the same bird as a Goose known to the Yorkshire fowlers of the 18th century as the Carr-lag. Mr. Coburn, as did Mr. Strickland, presumes that this is a Goose of aquatic habits, and so he accounts for its "long swan-like neck and large swan-like feet." Mr. Coburn says that the bird equals a fine Grey-lag in size, but its general tone of coloration of plumage resembles that of the Bean Goose. As regards the structure of the bill the serrations on the lower mandible "are large in size, sharply pointed, and directed backward, whereas in the Bean Goose they are straight, blunt, and more fused together."

Mr. F. W. Frohawk suggests *(The Field*, December 20th, 1902, p. 1045) that a Goose described as *Anser neglectus* by Mr. B. Sushkin *(Ibis*, 1897, p. 5) may be found occasionally in Great Britain This bird, Mr. Frohawk says, may be termed the large pink-footed Goose. Its bill is longer and more slender than that of *Anser brachyrhynchus.* Mr. Coburn and Mr. Frohawk are to be thanked for calling attention to these Geese, and it is to be hoped that their observations will lead to further material being collected so that the various species of British Geese can be authoritatively defined.

All contributions to the column, either in the way of notes or photographs, should be forwarded to Harry F. Witherby, *at the Office of* Knowledge, 326, *High Holborn, London.*

ANIMAL WIND-BAGS—USEFUL AND ORNAMENTAL.—II.

WIND-BAGS AS VOICE ORGANS.

By W. P. Pycraft, A.L.S., F.Z.S., etc

Although, as in the case of the great bustard and the pinnated grouse, the inflation of the air-sacs of the throat is associated with the production of peculiar sounds, caused by the violent expulsion of the air therefrom, the display of these wind-bags is, as a rule, silent. Or the sound is produced by the voice organ and not the sac, which is primarily, among birds at least, an ornamental appendage.

The wind-bags with which we are now to deal are in every instance devoted exclusively to the production of sound, musical or otherwise, which is designed, as in the foregoing instances, to attract and charm the female members of the community. Among the birds, it will be remembered, these peculiar wind-bags are sometimes formed by temporarily commandeering the services of the gullet, sometimes by the development of independent structures, as in the case of the throat-pouch of the great bustard; but the pouches now under consideration are in all cases specially developed organs borne only by the males.

The troubadours of nature are countless, but perhaps the quaintest of these minstrels are those which elect to declare the tender passion on the bagpipes. To our ears the music they produce is often as trying to the nerves as the noise produced by a child with its first drum; whilst in other cases we are charmed with the beauty of the melody. Doubtless, however, to those for whom they play, the music is in all cases equally charming! Among our own species, indeed, the musical sense is by no means uniform. To Europeans' ears, the musical efforts of the savage seem but a jumble of discordant sounds, whilst the productions of Mendelssohn or Beethoven, for example, may stir up the deepest emotions in our nature. In other words :—

> "There are nine and sixty ways of constructing tribal lays,
> And—every—single—one—of—them—is—right."

So far as we are concerned, the lays now under consideration are expressed in music without words; whilst, as we shall see presently, the peoples who furnish the subjects thereof hold very widely distinct positions in the animal kingdom. Doubtless it will come as a surprise to many to find that the humblest of these performers on wind instruments are to be found amongst the ranks of the much-abused and despised frogs and toads; creatures that for centuries have been looked upon with misapprehension and even loathing. Shakespeare appears to be the only one of the old-time writers who has discovered a single redeeming feature about these really inoffensive

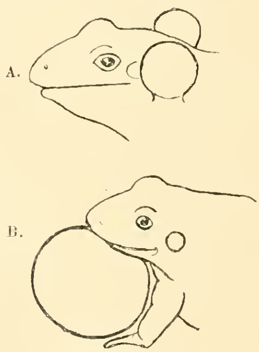


Fig. 1.—A. Paired Vocal Sacs of Edible Frog. B. Medium Vocal Sac of a Tree Frog.

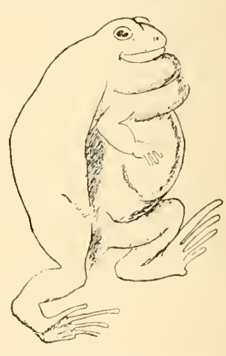


Fig. 2.—Dusky-spotted Marsh Frog of Paraguay, showing Air Sacs. (After Gadow.)

and useful creatures. Thus, in "As You Like It," Act II., he assures us that—

> "The toad, ugly and venemous, wears yet a jewel in its head."

Had he been acquainted with the discoveries of modern zoology he might perhaps have added, "and a musical box in its throat."

We of the British Islands are dependent upon an alien for our first-hand knowledge of musical frogs. This is the European edible frog, which is said to have been introduced, many years ago, into the Cambridgeshire fens, and parts of Norfolk, from France. Its performance, however, is, to our ears, rather of the barbaric than the æsthetic order. Nevertheless, in their own way the males of this species appear to be most assiduous musicians, playing out of sheer joy of living, not only during the

period of courtship but throughout the months of June and July. During this season, especially when the nights are warm and moonlit, the concert begins at sunset and continues till dawn. One of these musical evenings, conducted by a colony of these frogs in North Germany, where they are common, has been graphically described by Dr. Gadow. The tuning-up commences, he tells us, with a single note uttered by a few scattered individuals, "qwarr, oo-arr," or "coarx," "qwarr, oo-ar," "coarx." And then the choir-master commences with a sharp sounding "brekeke." This is the signal for the rest to begin, which they do with a will, bass, tenor, and alto, each performer filling his vocal sacs to bursting size, so that these bags look like a pair of floats, one on each side of the head. When several hundreds of these joyous creatures are indulging in this exercise, the din may be heard a mile off. In the Middle Ages it was customary, where these irrepressible creatures abounded, to keep a servant for the sole purpose of breaking up the concert by beating the pond, throwing stones, or otherwise disturbing the meeting! In Foulmire Fen and Whaddon, in Cambridgeshire, these frogs, in their palmy days, earned for themselves the names of "Whaddon organs" and "Dutch" or "Cambridgeshire nightingales."

The voice-pouches of these frogs form, when inflated, as we have already described, a pair of large globular bags, one on either side of the head. They are found only in the males, and are filled through a small opening in the floor of the mouth on each side of the tongue.

The vocal powers of the American bull-frog, a near ally of the edible-frog, are well known. Assembling in hundreds during the breeding season, the males give voice to a croak so loud as to be compared to the distant roaring of a bull, which can be heard, on a still night, for nearly a mile.

The blue tree-frog of Australia sends forth, at one time a croaking sound, at another a noise which has been compared to the barking of an angry dog. Stranger still, Dr. Goeldi, of Para, has recently described a Brazilian tree-frog, known as the "ferreiro" or "smith," which is possessed of a really wonderful voice, making a sound which is compared to the noise made by a mallet slowly and regularly beaten on a copper plate. Regular concerts take place in the forests where these frogs abound, the notes of several individuals varying in tune and intensity. When seized, this extraordinary creature utters a shrill cry which is compared to that of a wounded cat.

Another tree-frog, this time from North America, has a note which resembles a small bell. So, too, has one of the South American toads, its call-note being described as three bell-like notes, the middle one being the highest.

Darwin's narrow-mouthed toad is another species with a bell-like note. This species, by the way, is further remarkable in that the vocal sacs, during the breeding season, are used as a depository for the eggs! The safety of these treasures is of course of immense importance, but this particular arrangement for their security must be an exceedingly inconvenient one for the father of the family, inasmuch as, until the eggs hatch and the young are extruded, he is rendered perfectly dumb!

A remarkable species of frog recently discovered in Paraguay has a cry which has been compared to that of a kitten. The voice is made by alternately inflating the voice-pouches and lungs. When the latter are fully inflated this frog appears to be as big as a golf-ball, but if startled the air is immediately expelled, thereby reducing the body to one-fifth its former size.

Besides the examples we have selected for comment, the ranks of the lowly and much-despised frogs and toads boast many other performers quite worthy of honourable mention did space permit. It must not be supposed, however, that it is they alone who are provided with the curious dilatable sound-boxes; on the contrary, as we shall now proceed to show, they are to be found in various animals, up to the "lord of creation" himself.

Among the birds we have two very striking instances in the ostrich and the emeu. The ostrich, like certain other birds which inflate the neck for the purpose of display only, transforms his gullet, for the nonce, into a sound-producing organ. This is done by the male only, and when challenging another cock, or courting the female. The sound is described as resembling a muffled "boom," and its production is known by English ostrich farmers as "bromming." It can only be made whilst the bird is standing still, but exactly how it is produced is not quite clear. Possibly the huge column of air in the gullet serves in some way as resonator to the voice organ, whilst, on the other hand, the sound may be produced by the sudden expulsion of the imprisoned air.

The emeu, far inferior to the ostrich in many things, has decidedly the advantage in matters musical, inasmuch as it has developed a quite unique form of voice organ. This is formed by a long slit pierced through the wall of the front of the windpipe, near its middle, so as to permit the exit of a large pouch formed by the inner lining of the windpipe, so that the pouch comes to lie between the windpipe and the skin of the neck. Although present in both sexes, this pouch, strangely enough, appears to be used only by the female, who, during the time when the cares of a family weigh heaviest, gives voice to a very peculiar booming sound of considerable volume. That the sound is due to the action of the pouch there can be little doubt, for the true organ of voice in the emeu is of a very rudimentary character.

Voice pouches among the higher animals occur but rarely. Traces thereof are to be found, however, in certain whalebone whales and porpoises, some swine, and the great ant-eater, indicating that at some earlier time these creatures possessed, if not the gift of song, at least the ability to make a noise in the world.

In the common fox two voice pouches of considerable size are found in the larynx, though not large enough to be visible externally. Probably they are to be found in the wolf, hyæna, and jackal also, and aid not a little in the production of the blood-curdling sounds which these creatures are capable of pouring forth.

We meet with them again among the members of the monkey tribe, and in man. Among some of the former these pouches are of enormous size, yet, save in one or two cases, they are incapable of producing any sound which to our ears would be called musical; on the contrary, in many cases they make the night hideous by the most demoniacal of noises.

The howler monkeys of South America have achieved great distinction in this direction. Waterton, in his "Wanderings," writing of the red howler monkey of Demerara, tells us that "Nothing can sound more dreadful than its nocturnal howlings. While lying in your hammock in these gloomy and immeasurable wilds, you hear him howling at intervals from eleven o'clock at night till day-break. You would suppose that half the wild beasts of the forest were collecting for the work of carnage. Now it is the tremendous roar of the jaguar, as he springs on his prey: now it changes to his terrible and deep-toned growlings, as he is pressed on all sides by superior force; and now you hear his last dying moan beneath a mortal wound."

Some naturalists have supposed that these awful sounds, which you would fancy are those of enraged and dying wild beasts, proceed from a number of the red monkeys

howling in concert. One of them alone is capable of producing all these sounds.

The howler monkeys appear to have gone to considerable trouble and pains to produce these extraordinary sounds, for even the bones of the skeleton have been altered in consequence. The resonating voice pouch of these monkeys is formed by an outgrowth of the membrane lining the windpipe; to be more exact, of the inner lining of the larynx, the region of the windpipe which forms the "Adam's apple" in man. It is of enormous size, and to afford it support the bones of the tongue have been induced to form a huge cup-shaped chamber, and to protect this, the lower jaw has further developed abnormally deep sides, so that the long chamber with its thin-walled pouch is most effectually protected.

The man-like apes—the gibbons, gorilla, chimpanzee and orang-utan—are all provided with these peculiar pouches, and all have remarkably powerful voices.

The pouches of the gibbons are relatively small—in one species, the Siamang gibbon (*Hylobates syndactylus*) of Sumatra, they are said to be wanting—but at least two species are capable of producing musical sounds. Thus, the notes of the agile gibbon have been described as ascending and descending the scale, the intervals being exactly half tones. The highest note an exact octave higher than the lowest. The silvery gibbon, Mr. Francis Darwin tells us, sings in a cadence of three notes in true musical intervals, with a clear musical note. The wanwan gibbon (*Hylobates leuciscus*) is a decidedly less pleasing songster. Dr. H. O. Forbes, in describing this species, which he met with in Java, tells us that in the evening, just about sundown, and again, just before sunrise, the traveller is often startled by the sudden outbreak of what appears to be, now the loud plaintive wailings of a crowd of women, now the united howlings of a band of castigated children. Eventually the harrowed feelings of the listener are relieved by the discovery that these woeful cries are merely the outbursts of a band of monkeys serenading their neighbours.

The gorilla, chimpanzee, and orang surpass even the howler monkey in their ability to make a noise.

The gorilla is described as being able to emit "a terrible yell that resounds far and wide through the forest." The orang in producing high notes thrusts out his lips into a funnel-shape; but in uttering low notes the mouth is held wide open. The chimpanzee, like the howlers, give vent to loud cries, shrieks, and howls in the morning and evening and sometimes during the night, making a noise which can be heard for great distances.

So far, however, we appear to have more information concerning the size and structure of the voice pouches of the large apes than of the noises which they produce. These pouches are formed by outgrowths of a pair of cavities of the larynx or organ of voice known as the ventricles of the larynx. In the gorilla and the orang they are of enormous size. In the former they extend from the throat downwards over the breast to the armpits; whilst in the latter they encircle the neck, so as to give the creature the appearance of wearing a life-buoy beneath the skin. In the chimpanzee these sacs appear to be somewhat less developed, and are three in number, a median and two lateral.

In man himself it is interesting to notice vestiges of these pouches are found within the larynx, behind the "Adam's apple." It is, perhaps, fortunate that they have sunk into desuetude, for one trembles to think of the numerous street cries, brawls, and the efforts of peripatetic orators that even now harrow our feelings, magnified ten-fold by resonators of this description!

A GIANT AMONG SEALS.

By R. Lydekker.

Few generalisations have taken a firmer hold of the popular imagination than the notion that the animals of to-day bear no sort of comparison with their predecessors of the past in respect of bodily size, and that, so far as the giants of the animal kingdom are concerned, we are living in a dwarfed and impoverished world. Like most popular conceptions this idea contains a considerable element of truth mingled with a large amount of misconception. In the first place, there is no accurate definition of what is meant by "the past." If it mean only those epochs of the earth's history previous to the advent of man, it is unquestionably inaccurate. If, on the other hand, it also embrace the prehistoric portion of man's sojourn on the globe, it has scarcely a claim to be regarded as a fair or accurate statement of the true state of the case, seeing that the extermination of a very considerable percentage of the large animals of the epoch in question has been the work of man himself—a work, unhappily, which is still proceeding apace.

But in addition to this, the animals of one geological epoch are very frequently confounded with those of another, so that dinosaurs and mosasaurs, ichthyosaurs and plesiosaurs, mastodons and mammoths, and glyptodons and ground-sloths, are often spoken of as if contemporaries and inhabitants of the same country.

If such were really the case, we should indeed be living in an impoverished epoch of the world's history; but if we take the term "present" in not too narrow a sense, and also bear in mind that Europe, and such other parts of the world as have been more or less thickly populated for untold ages, scarcely form a fair basis of comparison, it will be manifest that the idea in question is to a considerable extent due to misconceptions and inaccuracies of the nature of those referred to above.

It is true that in certain portions of the world the larger forms of animal life disappeared at an epoch when man can scarcely be regarded as having taken a prominent part in their extermination; a notable example of this kind being South America, where the huge ground-sloths, toxodons, and macrauchenias of the latter part of the Tertiary epoch disappeared with seeming suddenness in what is to us an unaccountable manner. The extermination of the mammoth, the woolly rhinoceros, and the hippopotamus from Europe, although partly, perhaps, attributable to climatic change, has not improbably been accelerated by man's influence, and the same may be true with regard to some of the larger mammals of ancient India.

In the latter country we have, however, still the Indian elephant, the great one-horned rhinoceros, and the wild buffalo, which, although not actually the largest representatives of their kind, are still enormous animals. In Africa the prevalence of animals of large corporeal bulk is more noticeable. Although the extinct elephant of the Norfolk "forest-bed" is stated to have been the biggest of its tribe, it is very doubtful if it was really larger than the living African elephant; and the so-called white rhinoceros, in the days of its abundance, was certainly not inferior in point of size to any of its extinct relatives. The giraffe, again, which in the Mount Elgon district is stated to tower to twenty feet, is much taller than any extinct quadruped yet known to us; and the hippopotamus falls but little short of its ancestors of the Pleistocene epoch. The elands, again, are by far the largest of antelopes known at any period of the earth's history; and the ostrich, although not comparable with some of the New Zealand moas (which, by the way, were probably exter-

minated only a few centuries ago by the Maoris), is yet the largest member of its own particular group. Again, no fossil ape is known which is anywhere in the running as compared with a full-grown male gorilla. It is, moreover, probable, despite the old-world legends of giants, that man at the present day is, on the whole, a taller and finer animal than he ever was before.

Of course there are certain cases where the animals of to-day cannot compare with some of their predecessors, and a case in point is afforded by the extinct atlas tortoise of Northern India, which (although its size has been vastly exaggerated) far exceeded in bulk its living cousins of the Galapagos and Mascarenes. This, however, may perhaps be accounted for by the larger area of its habitat.

Among the inhabitants of the ocean we shall find even more striking testimony as to the large bodily size (either absolute or relative) attained by many animals of the present day. Probably no mollusc was ever larger than the giant clam, whose valves measure a yard or more in length; and we have no evidence that the enormous cuttles and squids, forming the food of the sperm-whale, were ever rivalled in size during past epochs. The huge long-limbed crab of the Japanese seas, and the cocoa-nut crab (which is but a marine creature that has taken to a terrestrial existence) of the islands of the Indian Ocean, are likewise probably the giants of their kind. At no epoch of the earth's history have we any record of an animal approaching in size the blue rorqual, with its length of between eighty and ninety feet, and its weight of, probably, at least as many tons. The sperm-whale and the Greenland right-whale were, at the time of their abundance, certainly the largest of their respective kinds; while the basking-shark has probably been unequalled in bulk by any of its predecessors. The great white shark of the present day is indeed considerably inferior in size to its cousins whose teeth now strew the floor of the Pacific, but these latter lived at no very distant period, and may possibly still survive. Walruses were never larger than they are at the present day, and the dugongs and manatis of the seas of our own days were fully as large as any of their ancestors of which we have ken; while the northern sea-cow of Bering Sea—exterminated only a century and a-half ago—was in this respect far ahead of all other competitors.

The same is true with regard to the anima forming the subject of the present article—the sea-elephant, or, better, the elephant-seal—which so vastly exceeds in size all other members of its tribe that even the largest sea-lions and walruses, when placed alongside its huge bulk, look dwarfs by comparison. But it is not only from its vast size that this seal is of more than ordinary interest, since it is remarkable for many peculiarities in structure and habits, approaching the eared seals (or sea-lions and sea-bears) more closely than is the case with any other of the true or earless seals. It has also, unhappily, an interest attaching to it on account of its impending extermination.

Elephant-seals frequent the shores of many of the islands of the South Seas, where they spend a long time on land during the breeding season, and also occurred formerly on the Pacific Coast of North America from Cape Lazaro to Point Reyes, California, where they are now practically extinct. As these Californian elephant-seals were completely isolated from those inhabiting the South Sea Islands, they are regarded by American naturalists as constituting a species by themselves; but since their distinction from the typical southern form is but slight, it seems preferable to look upon them in the light of an isolated local race. These seals never appear to wander south to the Antarctic pack-ice.

Our first definite, if not actual, knowledge of the elephant-seal seems to have been derived from a specimen brought to England by Lord Anson in 1744 from the island of Juan Fernandez, and the figure and account given in the "Voyage Round the World" of that great commander, where the species is called "sea-lyon." Lord Anson seems to have obtained a male and a female specimen ("lyon" and "lyoness" he calls them), the former of which was stuffed and exhibited in the British Museum. What its dimensions were is now unknown, a somewhat unfortunate matter, since it was probably a full-grown adult male of larger size than any, or the majority of those, to be met with at the present day. After being exposed in the Museum galleries for considerably more than half a century, probably without any protection from dust and the still more mischievous hands of visitors (who then, as now, doubtless displayed an irresistible impulse to handle every accessible object), the specimen must certainly have shown marked signs of wear and tear. Anyway, if we may judge by the fact that the jaws and teeth, which had been mounted in the skin, were sold by the Museum to the Royal College of Surgeons in 1809, the specimen appears to have been destroyed early in the last century. The aforesaid jaws and teeth are still preserved in the Museum of the College of Surgeons.

Although many years later a female skin, presented by the Admiralty, was mounted and exhibited, from the date of the destruction of Lord Anson's specimen the British Museum till quite recently had no example of either skin or skeleton of an adult male of this giant seal to show the public. The deficiency has been made good by the generosity of Mr. Walter Rothschild, and the mounted skin and skeleton of two nearly adult males are now exhibited in the same case. Unfortunately, the taxidermist has not been as successful as he might have been in the mounting of the skin, but nevertheless the specimens suffice to convey an adequate idea of the huge bulk of the creature, and the leading peculiarities of its form.

It may be mentioned here that Anson's figure and description afforded to Linnæus his only knowledge of the species, and upon this evidence was established his *Phoca leonina*, the specific title being the equivalent of Anson's "sea-lyon." As the real sea-lions are totally different animals—eared-seals, in fact—it is a great pity that this name was ever given, but, as being the earliest, it has to stand, and cannot be replaced, as proposed by some writers by the more appropriate *elephantina*. As the elephant-seal differs very widely from the common seal and its immediate relatives, it could not, of course, with the advance of zoological science, be suffered to remain in the same genus, and it accordingly now typifies a group by itself under the name of *Macrorhinus leoninus*.

The generic title *Macrorhinus* refers to the most distinctive feature of the species, the peculiar trunk-like form of the muzzle of the old males. Not only do the male and female elephant-seal differ in regard to the form of the muzzle (the trunk being undeveloped in the last-named sex), but there is also a vast inferiority in the size of the latter as compared with the former. So marked, indeed, is this discrepancy, that an early observer is stated in Weddell's "Voyage" to have mistaken the two sexes for mother and young.

From the testimony of old "beach-combers" and others who have hunted them in their native haunts, it seems evident that the dimensions now attained by sea-elephants fall far short of those reached in the old days, when they abounded on the islands of the South Seas, and were permitted to grow to their full size. In the majority of text-books twenty feet is given as the length of the species; but it is definitely known that specimens at the present

day frequently reach or exceed this length, and as none of these (as exemplified by the condition of the bones in the British Museum and other skeletons received of late years in England) appear to be fully adult, it seems well-nigh certain that old bulls must have grown to much greater size. Probably twenty-five feet would not be an undue estimate for the length of an adult male, and it is far from improbable that close upon thirty feet may have been reached in some cases.

Among the favourite haunts of the elephant-seal were the islands of the Crozet group, Kerguelan, and St. Paul, in the Indian Ocean, as well as Heard Island. In the South Atlantic these monsters formerly abounded on Tristan-da-Cunha, and nearer the American coast they are again met with further south on the Falklands, South Georgia, and the South Shetlands. On the eastern side of the Pacific they occur, as recorded by Lord Anson, on Juan Fernandez, and thence by way of the Marquesas to the Macquarrie and other islands south of New Zealand, where the British Museum specimens were obtained. They were likewise common on the coasts of Tierra del Fuego and Southern Patagonia; and the occurrence of the isolated colony north of the equator in California has been already mentioned.

The trunk-like muzzle of the old bull sea-elephant, like the sac on the crown of the head of its relative the bladder-seal, is capable of inflation during periods of excitement, but at other times is small and relatively inconspicuous. Probably it is only when the animals are on shore, and more especially during the breeding season, that the trunk is inflated to its full extent. The sketch in Lord Anson's "Voyage," although true to nature in some respects, is in many ways a caricature, and it is only of late years that photographs have been obtained showing the true form of the animal. From these it appears that when on land the old bulls are in the habit of supporting the fore part of the body on the front flippers and raising the neck and head into a nearly vertical posture, so that the latter is fully six feet above the ground. When the trunk is inflated to its fullest extent, the mouth is opened, and the animal emits a succession of terrific roars, which may be heard for miles.

In using its front flippers as a means of support to this extent, the elephant-seal is quite unlike the rest of the earless seals, and resembles the sea-lions and sea-bears. It also agrees with the latter group in the great superiority of the males to the females in point of bodily size. A third point of resemblance between elephant-seals and eared-seals is shown by their breeding habits, which are in many respects similar. On the Crozet Islands, for example, where they arrive about the middle of August, the old bulls secure a station for themselves. They do not, however, pass any long period without taking food, neither do they collect "harems" for themselves after the manner of the sea-bears and sea-lions; the females selecting a station for themselves some distance away. Soon after landing the females give birth to their young, which are at first black, and, although there is some discrepancy between different accounts, it seems probable that both sexes remain with their offspring till the latter are ready to enter the sea, which they usually do when about six or seven weeks old. When they have once taken to a maritime life the young sea-elephants are said to grow at a prodigious rate; and, indeed, unless they take many years to attain full maturity, this must necessarily be the case.

As just indicated, the few accounts that have been given of the breeding habits of these seals by no means accord with one another, and this is the more to be regretted since, owing to the comparative scarcity of the species at the present day, it is very unlikely that an authentic history will ever be given to the world.

The extermination of this giant seal, so far as it has as yet gone, is a sad story, accompanied as it is by details of revolting and fiendish cruelty. In the eighteenth and the early part of the nineteenth century these seals were met with in thousands on most of their island haunts as well as on the shores of Patagonia, but the ease with which they could be killed, and the value of their hides and oil, soon led to a vast reduction in their numbers; and in many of their old breeding-places, such as the Falklands, they are either very scarce or are altogether exterminated. On Heard Island they still survive in considerable numbers owing to the difficulty of gaining access to their favourite breeding-ground, to reach which from the shore two glaciers have to be crossed. The difficulty of removing the oil and hides from such a locality has, however, been to a considerable extent overcome by driving the seals to sea during stormy weather, when they are compelled to seek an easier landing-place. In the Macquarrie Islands elephant-seals appear to be still obtained in considerable numbers, but the difficulty, or impossibility, of obtaining a fully adult male tells its own tale as to the persecution to which the species is subject; and it is only too palpable that long before the middle of the present century elephant-sealing will have been abandoned as an unprofitable trade; but by that time we shall really be living in an impoverished world, so far as large animals are concerned.

MICROSCOPY

Conducted by M. I. Cross.

NOTES ON THE COLLECTION, EXAMINATION AND MOUNTING OF MOSSES AND LIVERWORTS.

By T. H. Russell.

The following notes, which simply represent the conclusions drawn from a good many years' practical observation and experience, and do not pretend to anything more abstruse or scientific, are written in the hope that they may not only prove of service to others interested in the above fascinating little plants, but may also be the means of eliciting further information on the subjects of which they treat from those whose researches have been more extensive than my own. For the sake of convenience I shall only directly refer to mosses, though all that I have to say will apply equally to the liverworts.

I.—Collection and Examination.

The appliances for the collection of specimens are simple in the extreme. For many years I have been in the habit of putting the material gathered in the field into old envelopes that have been cut open at the narrow end instead of at the side. Not only do these form the most convenient pockets for the purpose, but notes can be made on them at the time, of the date and locality, when and where the plants were found, and rough memoranda may be added afterwards of any special features of interest that present themselves on a closer examination of the contents, and that need elucidation. A bundle of these envelopes, with a fairly strong magnifying-glass, an old knife, and a pair of forceps constitute my usual outfit, and are kept ready for use in a small satchel, which serves as a receptacle for the envelopes when filled. The forceps are useful for detaching plants from their surrounding earth, an operation that can often be best performed when they are freshly gathered. On reaching home the envelopes that have been used are placed in a warm room, in an upright position, and with the ends opened as widely as possible so as to admit air, and thus to allow

the specimens inside to dry, a matter of no small moment if the risk of mildew is to be avoided. After standing thus for a few days the envelopes can be safely folded over at the ends and put away until a convenient opportunity occurs for examining the contents, when soaking in hot water will speedily restore the plants to their original freshness, though not, of course, to life. The ease with which mosses can in this way be revived for examination constitutes, to my mind, one of the chief attractions which this branch of botanical research offers to anyone in search of a hobby, for while the gathering of specimens forms a healthy out-door occupation for all seasons of the year, and adds immensely to the pleasure and interest of a ramble in the country, their examination and mounting may be deferred for any length of time, and will provide the most pleasurable recreation by the fireside in the long winter evenings, and will bring back the memory of many a happy day in the woods and fields.

The nature of the apparatus used in the examination of specimens will, to a large extent, depend upon the views and means of the student. A microscope of some kind is essential if the study is to be followed up with any degree of thoroughness, though much good work may be done with a comparatively inexpensive instrument; at the same time it is no doubt true that, within certain limits, the better the implement the better the results to be obtained by its use. My own experience would lead me to say that, if the funds will allow, the binocular model is greatly to be preferred to the monocular, if only on account of the saving of strain to the eyes that is thereby effected. Objectives of high power are seldom required; I generally work with 2 in., 1 in., and ½ in. lenses, to which may be added a 3 in., which is especially useful in the exhibition of slides. To prepare specimens for examination or for mounting, some form of dissecting microscope is practically a necessity. For many years I used an ordinary magnifying-glass, of low power, fixed in a light metal frame, at one end of which was a small collar, which slipped over a screw fixed in an upright position in a small metal stand, and provided with a nut by means of which the lens could be fixed in a horizontal position at any required height, and this simple expedient is still often very serviceable. As a rule, however, I now employ the more modern binocular form of dissecting microscope, which is also of the greatest assistance in mounting. For soaking the mosses in hot water I have found nothing so handy as the small china saucers, made in different sizes, and sold by artists' colourmen. For dissecting purposes ordinary sewing needles set in cedar pen-holders are useful in the more delicate work, and it is well to have one or two bent at an angle to the holder, for the purpose of altering the position of objects under examination after the cover-glass has been put on; these, moreover, will be found invaluable in subsequent mounting operations. In order to bend a needle into almost any form it is only necessary to heat it in a spirit lamp to a red heat, and then plunge it into water, this will render it soft and pliable. The best dissecting implements, however, for ordinary work that I know of are made by fixing glovers' needles into handles in the above manner. I use Mogg & Co.'s glovers' needles, No. 4. They can be obtained at a small cost at any drapers, and are not only provided with a fairly good point, but are ground with three flat faces, thus giving as many cutting edges, by the help of which the specimen can be most effectually prepared for examination and mounting. A pair or two of forceps (one with curved ends), a pair of small scissors, a small camel's-hair brush, and one or two small lancets will practically complete the implements required for all ordinary dissecting, to which must be added, for the purpose of microscopical examination and subsequent mounting, a stock of the usual glass slips (3 in. by 1 in.), and a few sizes of cover-glasses. With many of the larger mosses the square cover-glass (⅞ in. and ¾ in.) is best, as it gives more mounting surface, while for the mounting of pieces of moss of considerable size, cover-glasses that are specially large should be procured.

(To be continued.)

PHOTOGRAPHY OF OPAQUE OBJECTS.

By Frederick Noad Clark.

(Continued from page 20.)

Perhaps the most useful all-round objective for this work is the 2-inch; a lower power than this we have found of no advantage when depth of focus is an object. The use of a stop in the form of an iris diaphragm or a Davis' shutter is sometimes necessary, it being fitted just above the objective. This will increase the depth of focus when photographing spherical objects or those lying in different planes; but the exposure is necessarily prolonged.

A plate giving the maximum amount of density is necessary. For this purpose any of the well-known makes of isochromatics are best. They must invariably be "backed." The developer should be dilute, and if pyro-soda is used (which we recommend) the pyro should be used sparingly. Development ought to be slowly carried on to full density, the aim being to obtain a negative with plenty of contrast, without blocking of the high lights. It is to give this effect that the backed plate is so essential.

As to length of exposure no exact information can be given. As a rough guide it has been found that using a 2-inch objective with direct illumination by means of the bull's eye from a good paraffin lamp with a 1-inch wick, the exposure at 20 diameters will vary from 2 to 3 minutes according to the colour of the object; a white object naturally requiring a less exposure than a darkly-coloured one. As further examples we may mention those of Foraminifera at 8 diameters with a 2-inch requiring 30 seconds exposure, whilst Polycistina at 45 diameters and a 1-inch objective required 30 minutes.

When photographing objects too large for the field of a micro-objective, lenses of the Planar type will be found convenient. These, in conjunction with a long-extension camera, will give a magnification of from 2 to 10 diameters.

The eggs of insects, particularly those of the Lepidoptera, lend themselves admirably to photography. Especially suitable are those of the Lycaenidæ, or blue butterflies, their small size and elaborate structure rendering them most beautiful objects for opaque photography.

We would impress upon the worker the advisability of photographing these objects at the same magnification whenever possible, in order to give a proper idea of their relative sizes. Two or more aspects of the same object are sometimes desirable, as in the case of ova, where an upright and a lateral view are frequently of importance.

Many other subjects for opaque photography might be mentioned, such as the hairs and seeds of botanical specimens, fern spores and micro-fungi, whilst some of the larger Diatoms, Foraminifera, and Polycistina are eminently suitable for this class of work.

Working with a Polariscope.—The number of microscopists who use the polariscope for scientific work is exceedingly limited, by comparison with those who find in this adjunct a never-failing source of pleasure and variety, but whether it be used for colour effects or for scientific observations, there can be but one opinion as to the disadvantages produced by the prisms, and particularly when the analyser is used over the eyepiece. It seems well-nigh impossible to get a prism of moderate size which will fill the whole field of the eyepiece, and there is invariably a disagreeable dark patch on the margin of the field. Further, the necessity of working with the eye some distance from the eyepiece lens reduces, in some measure, the sharpness of effect.

In a lesser degree, the polarising prism interferes with the best performance of the substage condenser, and working is practically limited to condensers having small lenses, otherwise the prism would act as a diaphragm.

Mr. E. M. Nelson communicated a special note on this subject to the April (1902) *Journal of the Royal Microscopical Society*, and therein indicated the advantages of using tourmalines instead of prisms.

One tourmaline (which need not be of best quality), measuring about 4/10th by 6/10th, should be mounted in a metal screen, with an aperture of such a size as to prevent any light passing from the lamp, except through the tourmaline. This screen may be held on a separate stand, or in an extra frame attached to the lamp chimney. This would act as the polariser, and the image of the lamp flame could be focussed with the condenser, in the usual manner. Another tourmaline, which must be as perfect as can be obtained of "smoky tint, with the slightest dash of pink," is fitted over the eyepiece. With this in use, the best effects obtainable with the polariscope will be obtained,

the highest powers can be used, and no deterioration in definition will result. Those who may not think it necessary to go so far as is here suggested, may with advantage fit a tourmaline over the eyepiece only to act as the analyser, and this will polarise perfectly well in conjunction with a prism in the substage.

Tourmalines have not been generally employed on account of the difficulty of securing suitable pieces and the high cost of such; but if a general demand were to arise there is no doubt that with an effort it could be met. It should be emphasised that the plate used over the eyepiece if at all thick or dark will materially diminish the brightness of the image. Poor tourmalines will polarise, but without that brilliance which adds to the beauty of the effects.

Mr. Nelson particularly points out that an apochromatic condenser should not be used in polariscopic work, because the fluorite, which is used in its construction, will also be polarised.

NOTES AND QUERIES.

J. Hills.—Mr. Mason, of 69, Park Road, Clapham, S.W., supplies specimens ready prepared for mounting. If you applied to him for a list you would no doubt be able to obtain what you required.

P. B. Gray.—It is almost impossible to identify the specimen you describe and sketch without actually seeing it, but it probably is *Anobium paniceum.* This is a common pest in stores, &c.

General Warrand.—The specimen you describe and sketch is no doubt the test of the Rhizopod *Arcella vulgaris* or *A. discoides.* The best cement to attach ordinary glass cells to slides is either gold size, Hollis's glue, or Miller's cement. The permanence of the preparations depends on the finishing varnish which you use. Mr. Rousselet has given many years of experiment to this particular subject, and he now recommends that the closing of the cell should be first with a coat of a varnish consisting of two-thirds damar in benzole and one-third gold size, then two coats of pure shellac dissolved in alcohol, and finally four to six coats of pure gold size. Each layer of cement must be allowed to dry thoroughly well; three days for each layer is not too long.

W. D. Dade.—The specimens of which you send a sketch for identification are probably *Hemiophrya benedeni Fraip.* It appears to be a salt-water Infusorian.

W. P.—The most complete work for naming Diatoms is Schmidt's Atlas. This has been published in separate parts, which now number sixty. The value of this work is between £15 and £20, according to its state of preservation. A less expensive book is Van Heurck's "The Study of Diatomaceæ," translated by Mr. Wynne E. Baxter. The price of this is 50s.

J. E. Storey.—It is almost impossible to indicate in print tests for objectives of larger aperture such as you possess, because some workers are able to do so much more with their lenses than others, and it would probably happen that you would still be in possession of good objectives even if you could not accomplish the same work as others. Experienced workers can usually form a very accurate opinion of a lens with simple rather than extreme tests, but it would be impossible to give reasons for deductions in a reply such as this. Perhaps some reader may know the refractive indices of Farrant's medium, glycerine jelly, and acetate of copper solution.

Rev. S. R. Craig.—Notes from time to time appear on photomicrography, and an attempt is being made at present to give hints on aspects of the subject which are not usually treated. I may be glad of the loan of your photographs at a subsequent date.

W. H.—To mount vinegar eels (*Anguillula aceti*) add a little chloroform to the vinegar to kill the eels. When the eels have settled to the bottom of the bottle, pour off the vinegar, and add camphor water or carbolized water. Mount in a shallow cell in the same fluid.

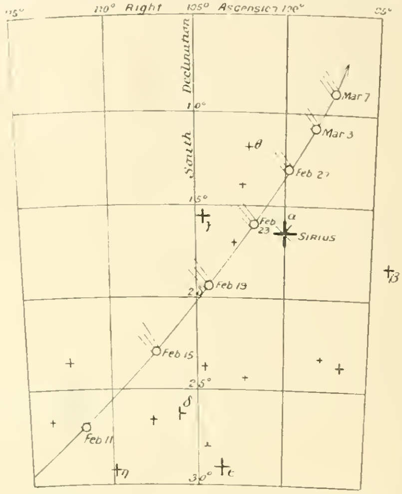
Consultants.—I shall be very glad of the assistance of a reader in the naming of polyzoa, algæ, etc.

Communications and enquiries on Microscopical matters are cordially invited, and should be addressed to M. I. Cross, Knowledge *Office,* 326, *High Holborn, W.C.*

NOTES ON COMETS AND METEORS.

By W. F. Denning, F.R.A.S.

Perrine's Comet (1902 b).—This comet will be visible in the evening sky before moonrise on February 13 and ensuing nights. Towards the end of the first week in March moonlight will obliterate the object, and it will hardly be seen again in ordinary telescopes owing to its rapid decline in apparent brightness. At about the middle of February the comet souths soon after 9 p.m., but will be only some 15 degrees above the horizon at Greenwich. Moving rather quickly to the north-west it will south at about 8 p.m. on February 27, at an altitude at about 25 degrees. Its approximate path amongst the stars of Canis Major is shown on the following diagram. A little sweeping in the position indicated will probably reveal the comet as an elongated nebulous object of about the same apparent brightness as when first discovered on the morning of September 1 last.



Path of Perrine's Comet (1902 b). 1903, February 11, to March 7.

Giacobini's Comet (1902 d).—This comet will be somewhat brighter than in preceding months, though still very inconspicuous. Its favourable position in the heavens will enable it to be well observed during the last half of February. On December 30, as viewed in a 10 inch reflector by the writer at Bristol, the comet appeared about magnitude 11 and 30″ in diameter. The following is an ephemeris:—

Date 1903.			R.A. H.	M.	S.	N. Dec. °	′	Brightness.
January	26	...	6	43	56	12	13	1·77
February	11	...	6	36	36	17	40	1·65
,,	27	...	6	35	44	22	36	1·49
March	15	...	6	42	4	26	42	1·29
,,	31	...	6	55	12	29	59	1·08
April	16	...	7	14	8	32	27	0·90
May	2	...	7	37	50	34	13	0·77

The Great Meteorite of Sinaloa, Mexico.—An interesting description of a visit to, and analysis of, this object is given by Mr. H. A. Ward, of Rochester, New York, in the *American Geologist* for October last. The great meteorite lies on a farm about seven miles due south of Bacubirito, an old mining town on the Rio Sinaloa, in latitude 26°, longitude 107° W. The meteorite is described as "a long monstrous boulder of black iron, which seemed to be still burrowing to hide itself from the upper world." By the aid of 28 men the object was uncovered and found to be 13 ft. 1 in. long, 6 ft. 2in wide and 5 ft. 4 in. thick. Mr. Ward concluded that this body is the largest and heaviest of its kind known to exist on our globe, and estimates its weight as 50 tons. A piece weighing 11 pounds was detached, and on being polished and etched the Widmanstätten figures were exhibited in a beautiful manner. Prof. J. E. Whitfield, of Philadelphia, gives an analysis as follows:—

Specific Gravity ... ... 7·69

Iron ...	88·944	Sulphur ...	0·005
Nickel ...	6·979	Phosphorus ...	0·154
Cobalt ...	0·211	Silica	trace,

THE LEONIDS OF 1902.—These meteors were keenly awaited at many of the principal observatories in America, but apparently with very little success. Cloudy weather seems to have been very prevalent and to have practically effaced the display at most stations, while at other places where partial observations could be taken there was no evidence of an abundant shower. Very few complete reports appear, however. to have been published. and the explanation seems to be that the sky presented very little considered worthy of record. At Dublin Mr. J. R. Henry noticed no Leonids before midnight on November 14, though a small fireball appeared at 10h. 55m., passing from the direction of Orion to a few degrees above and beyond Castor. On November 17 the same observer counted 8 or 10 shooting stars between the hours of 14 and 15. flashing from the constellation Leo. Some of these objects were probably true Leonids, for though the date appears somewhat late for an active return of this stream, it is certain that Leonids are occasionally distinguished until the end of the third week in November.

Moonlight and clouds, which in a great measure marred the Leonid display, appear to have equally interfered with the Geminids. Indeed, very few meteors could be discerned in the gloomy and frequently overcast skies of December. The year generally will be remembered as one singularly unfavourable for meteoric work, and as retaining this character right up to the end.

THE FACE OF THE SKY FOR FEBRUARY.

By W. SHACKLETON, F.R.A.S.

THE SUN.—On the 1st the sun rises at 7.43 and sets at 4.45; on the 28th he rises at 6.52 and sets at 5.34.

Small groups of sunspots may be expected.

THE MOON:—

	Phases.	h. m.
Feb. 5	☽ First Quarter	10 13 A.M.
,, 12	○ Full Moon	0 58 A.M.
,, 19	☾ Last Quarter	6 23 A.M.
,, 27	● New Moon	10 20 A.M.

The moon is in perigee at 1 P.M. on the 10th, and in apogee at 1 P.M. on the 22nd.

OCCULTATIONS.—The following are the principal occultations visible at Greenwich:—

Date.	Star Name.	Magnitude.	Disappearance. Mean Time.	Disappearance. Angle from N. Point.	Disappearance. Angle from Vertex.	Reappearance. Mean Time.	Reappearance. Angle from N. Point.	Reappearance. Angle from Vertex.	Moon's Age.
			h. m.	°	°	h. m.	°	°	d. h.
Feb. 6	δ^2 Tauri	4·7	9 45 P.M.	37	5	10 30 P.M.	315	278	9 5
,, 7	115 Tauri	5·4	10 13 P.M.	125	92	11 40 P.M.	240	201	10 6
,, 9	λ Geminorum	3·6	3 56 P.M.	75	115	4 49 P.M.	291	331	11 23
,, 9	68 Geminorum	5·0	11 21 P.M.	126	109	0 25 A.M.	260	231	12 7
,, 11	*h* Leonis	5·4	9 30 P.M.	74	104	10 27 P.M.	322	343	14 5
,, 14	υ Leonis	4·5	4 47 A.M.	141	113	5 45 A.M.	264	230	16 12

THE PLANETS.—Mercury is in inferior conjunction with the sun on the 2nd; he attains his greatest westerly elongation of 26° 58′ on the 27th, when he rises about an hour in advance of the sun.

Venus is an evening star in Aquarius. At the beginning of the month the planet sets about an hour and a quarter after the sun, whilst at the end of the month she sets two hours after the sun. Near the middle of the month the semi-diameter of the planet is 5″·3, and the illuminated portion of the disc is 0·95.

Mars is in Virgo, rising about 10 P.M., and therefore well placed for observation. He is easily picked up by his brightness and ruddy colour. On the 15th, at 11 P.M., the planet is near the moon, Mars being 3° 22′ to the north. The diameter of the planet is 11″·0, and 0·94 of his disc is illuminated.

Jupiter is unobservable, being in conjunction with the sun on the 19th.

Saturn is a morning star, but for all practical purposes is out of range, as he rises less than an hour before the sun.

Uranus rises in the early morning, about 3 A.M., and this, together with his great southerly declination of 23°, makes him an unsuitable object for observation.

Neptune is in Gemini and well placed for observation, being visible throughout the night. As will be seen by the chart given in last month's issue, the planet is near η Geminorum.

THE STARS.—The positions of the principal constellations near the middle of the month at 9 P.M. are as follows:—

ZENITH . Auriga.

SOUTH . Orion, Gemini, *Procyon*, *Sirius*, Cetus, Pleiades, Taurus to the S.W., Cancer and Hydra to the S.E.

WEST . Andromeda, Aries, Pisces, with Pegasus and Cygnus to the N.W.

EAST . Leo, Virgo.

NORTH . Ursa Minor, Draco, Cepheus, Ursa Major to the right of Polaris.

Minima of Algol occur at convenient times on 2nd at 7.11 P.M., 20th at 0.5 A.M., 22nd at 8.54 P.M., and 25th at 5.43 P.M.

Chess Column.

By C. D. LOCOCK, B.A.

Communications for this column should be addressed to C. D. LOCOCK, Netherfield, Camberley, and be posted by the 10th of each month.

Solutions of January Problems.

No. 25.

Key-move.—1. Kt to Q4.

If 1. . . . K × Kt, 2. B to B6ch.
1. . . . Kt to B4, 2. Q × Ktch.
1. . . . Kt × P, 2. Q to Q7.
1. . . . P to Q7, etc., 2. Kt to B3ch.
1. . . . K to Q3, 2. B to B4ch. mate.
1. . . . Anything else, 2. Q to K6ch.

[There are duals, etc., after all other moves of the Knights, except Kt to Q4, also after moves of the RP, and any move of the Bishop which does not guard White's KB3. Not more than three points can be scored for duals, since all of them contain one of the three combinations, (1) QK6ch and KtB3ch; (2) QK6ch and Q × KtPch; and (3) QQ7 and KtB3ch.]

No. 26.

Key-move.—1. Q to Kt3.

If 1. . . . K to B4, 2. R to B5ch.
1. . . . K to K4, 2. Q to Q3.
1. . . . P × P, 2. Q to Kt5.
1. . . . P to B3, 2. Q to Kt4ch.
1. . . . P to B4, 2. Q to Q3.
1. . . . Kt moves, 2. Q to B3ch.

SOLUTIONS received from "Alpha," 4, 4; W. Nash, 7, 4; G. A. Forde (Capt.), 0, 4; "W. Jay," 7, 4; "Endirby," 7, 4; "Looker-on," 7, 4; A. H. H. (Croydon), 7, 4; W. H. S. M., 7, 4; G. W. Middleton, 7, 4; F. Rickards, 0, 0;

"Tamen," 5, 4; "Quidam," 4, 4; J. W. Dawson, 7, 4; J. W. Dixon, 7, 4; C. Johnston, 7, 4.

"*Tamen.*"—Two out of your four communications were posted too late.

G. W. Middleton.—I much regret the cause of your retirement last year, and am glad to find that you have been able to resume solving.

G. F. Todd.—Your solutions were posted too late to count. It is not in my power to make any exceptions.

G. A. Forde (Capt.).—1. Kt to Q8 is answered by 1. . . . Kt to Q4, the only defence.

F. Rickards.—By Kt to Q6 I must assume you meant Kt to Q8, since you give as a variation 1. . . . K to Q5, without mentioning the capture of the Knight. Other incorrect variations confirm my suspicions.

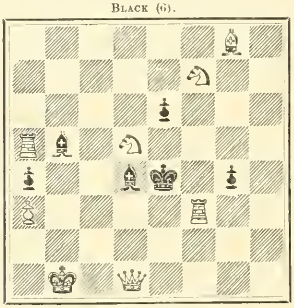
C. Johnston.—No one is more glad than the Chess Editor.

PROBLEMS.

No. 1.

By C. C. W. Sumner.

BLACK (6).



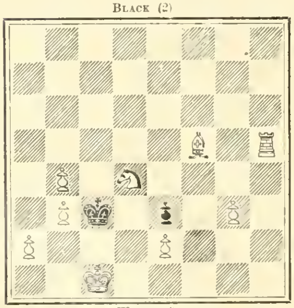
WHITE (8).

White mates in two moves.

No. 2.

By A. Lillie.

BLACK (2)



WHITE (9)

White mates in three moves.

[This problem is remarkable for the fact that its composer, after the lapse of some years, found himself quite unable to solve it.]

I should be greatly obliged if solvers would in future send *key-moves* only, omitting, at any rate, such variations as are free from duals. The solutions of two solvers this month occupy some ten or a dozen pages of MS.—considerably more than all the remainder put together. In their interests, as well as my own, I shall hope for some condensation in future.

PROBLEM TOURNEY.

The following six solvers, none of whom failed in more than two of the tourney problems, are eligible to serve on the preliminary jury, viz:—Messrs. "W. Jay," "Looker-on," W. Nash, J. W. Dawson, C. Johnston and G. Woodcock. As the number is very select, I hope that all of these will be willing to give their awards, which should be posted not later than February 22nd. If, however, they could find it convenient to send them with their solutions on or before the 10th, I should be much obliged. With a lighter task before them this month, perhaps they could manage this. Each list sent in must contain six problems arranged in order of merit. Brackets may be used if desired, and more than six problems *may* be included, *provided that all after the fifth are bracketed last.* To a problem placed first on any list I shall give 10 points, to one placed second, 9 points, and so on, so that a problem placed sixth will (apart from brackets) receive 5 points. This appears to me fairer than the system of marking from 6 down to 1; for on that system a problem placed first by a single judge, and omitted by the other five, would score more than a problem placed sixth on five lists. Whereas the latter composition would clearly be of some merit, and the exalted position of the first-mentioned problem might well be due to something accidental or extraneous. The marks awarded to each problem will then be added up, and those six problems which obtain the highest aggregates will alone be considered in my final award. Should, however, the next *one* or *two* come very close, I should reserve the option of taking them into consideration. I have already suggested that any problem which has proved a stumbling-block to any of the "jury" should receive special attention from its victim.

The result of the SOLUTION TOURNEY has not been challenged, and now becomes final.

All manuscripts should be addressed to the Editors of KNOWLEDGE, 326, High Holborn, London; they should be easily legible or typewritten. All diagrams or drawings intended for reproduction, should be made in a good black medium on white card. While happy to consider unsolicited contributions, which should be accompanied by a stamped and addressed envelope, the Editors cannot be responsible for the loss of any MS. submitted, or for delay in its return, although every care will be taken of those sent.

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CONTENTS.

ST. SOPHIA, CONSTANTINOPLE.

By E. M. Antoniadi, F.R.A.S.

Illustrated from original drawings by the Author.

II.

The Inner Division of the Church.

The first section of the present study on the great cathedral has dealt with its history and outer appearance, and it is now the design of this, as well as of the two succeeding sections, to describe the interior; starting with the inner division of St. Sophia during the 858 years it remained in the hands of the Christians.

To render the argumentation on this subject intelligible it is necessary to accompany it with a plan of the church. Fig. 4, which meets this requirement, is mostly the result of the writer's own direct measurements, except for the now inaccessible parts of the building, where Salzenberg's data* have been utilized. The plan further gives a synthesis of the results of Paul the Silentiary, Constantine Porphyrogenitus, the Anonymous Greek author, Grelot, Neale, Byzantios, Lethaby and Swainson, followed by the writer's analysis.

It should not be assumed that the new interpretation of the inner arrangements of St. Sophia is at all meant to be final or decisive. Such an inquiry, it must be remembered, treads on treacherous ground, where hasty conclusions and unjustified assertions are particularly dangerous. The plan is, therefore, at best, a first approximation, subject to all such modifications as would be rendered imperative by further investigation.

The Ambo or Pulpit.—In modern Greek churches the pulpit is to the left of the nave. But this was not its original position in the great cathedrals of the past. According to the poet, the Ambo of St. Sophia stood "in the sunshiny centre of the nave, but rather inclining eastwards." * Also, Germanos, Patriarch of Constantinople, mentions that "the ambo stands in front of the door of the sanctuary." Again, Symeon of Salonica speaks of "the ambo before the bema," adding that "it is placed opposite the sanctuary, provided the church is spacious enough to allow of such an arrangement."† These remarks leave no doubt as to the position of the pulpit: it was in the middle of the nave, on the great axis, but decidedly nearer the eastern wall. It must have been somewhere under the great arch to the east, in the position assigned to it by Messrs. Lethaby and Swainson,‡ and not under the central square area, as, in that case, it would interfere with the circle of lamps hanging from the cornice of the dome.

The Choir of Singers is described by Paulus as divided into two parts, each half "embraced" by the two eastern exedras.

Sanctuary, Soleas and Imperial Throne.—A curious feature of the ground floor to the east is that, through time or intention, it no longer forms a plane surface. The Bema or Sanctuary is reached to-day by three steps from the west, and by as many from the south, but by only two on the north side. The western steps, constituting the Soleas,§ are now approximately turned towards Mecca, forming an angle of some 18° with the minor axis,‖ so that it is almost impossible to conjecture their original design. Under such circumstances, the disposition given them in the plan is very uncertain, although there can be no doubt that the Soleas was originally much larger than what it is in modern Greek churches.

It would seem that there always was an Imperial Throne somewhere about the Choir or Soleas. True, such a throne is not mentioned by Paulus in the sixth century, nor by Porphyrogenitus in the tenth. But the statements of Sozomenus and Theophanes are eloquent on this point. "The king's place in the church," says the former of these authors, "is in front of the sanctuary, so as to enable him to preside, on one side, over the people and, on the other, over the priests"; while Theophanes remarks that "the custom of having the kings standing outside the sanctuary, with the people, held good" up to his time (9th century) It will be seen on the plan that the Imperial Throne has been placed by the writer to the south, in the position of the modern archiepiscopal throne

* *Altchristliche Baudenkmale von Constantinopel*, Berlin, 1854. It was not without some reluctance that Salzenberg's representations of the annexes now closed were incorporated in Fig. 4, owing to the great untrustworthiness of the German artist, who, although having had unique opportunities with the scaffolding and unveiling of the mosaics in 1848, could not avoid, in his plates, a series of glaring, and, indeed, unaccountable, architectural oversights.

* Paul the Silentiary, *Descriptio Ambonis*, verses 50, 51.

† Du Cange, *S. Sophia*, §74.

‡ *S. Sophia*, Fig. 5.

§ Probably from *soleum*, a throne.

‖ The perpendicular to these steps does not appear to face Mecca, whose azimuth from Constantinople is 331°, so that the faithful, praying in the mosque, and wishing to face the Kaaba, ought to incline slightly to the right.

of the Greeks. But it might also have been quite close to the Sanctuary, in the position marked A, on Fig. 4, where the marble decoration of the pier shows some curious anomalies, which it is not easy to account for on the basis of other assumptions.

Metatorion.—The word μητατώριον seems to come from *mutatorium*, and meant a vestiary. There were several Metatoria in St. Sophia, but the most important lay south of the Sanctuary, as ably pointed out by Messrs. Lethaby and Swainson.* Paul the Silentiary speaks (verses 165-168) of a "wall" in south aisle, "screening off the king on great feast-days," and enabling him "to hear, from his usual throne, the reading of the books celebrating the holy mysteries"; while we learn from Constantine Porphyrogenitus that, on attending service in the tenth century, the emperor spent a considerable part of his time in the Metatorion, where, of course, there must have been a throne, granting him some rest after the numerous processions he had to attend upon during the celebration of the liturgy.

Annexes of the Sanctuary.—Right and left of the apse, the openings of the eastern wall show evidence of having been originally subordinated to the presence of a series of low attached chambers, whose saddle roofs can still be traced from the south gallery of the church. Not only the windows are opened here at an unusual height, but also the great doors to the east lack centering with reference to the axis of the aisles. Communication with these chambers was ensured from the Sanctuary by two small doors, of which the one to the south is still extant, though blocked up so as to lead only to a shallow recess of the eastern wall.

There is good reason to believe that the *Prothesis*, or table destined to receive the bread and wine for the sacrifice on the Altar, lay in one of the northern chambers (Prothesis I. of the plan), and that most of the other halls constituted the *Sacristy*, *Skeuophylakion*, or *Diaconicon*. The addition of the high buttress masses of Andronicus Paleologos must have introduced serious trouble here, in 1317, by blocking with stone and mortar the all-important annexes. It does not seem improbable, therefore, that, during the last 135 years of the empire's existence, the Prothesis was in the aisle (Prothesis II.), immediately to the left of the Sanctuary; while a special streng circular building had to be erected as Sacristy, outside the north-east angle of the church.

The north porch to the east was the *Women's Narthex*. "On leaving the skeuophylakion," says Porphyrogenitus, "the emperor passes through the women's vestibule, where stand the deaconesses of the great church, and goes out through the left of the sanctuary."†

The Holy Well.—In his work on the Palace of Constantinople, Labarte raised a series of annexes all along the south wall of St. Sophia, for which, however, there is no trace of evidence, architectural or historical; and the fact that these annexes would inevitably block the windows of the southern ailes is a fatal objection to their assumption. Speaking of the celebrated Holy Well, Labarte, in his customary dogmatic spirit, says:—"From the great hall of the holy well one entered the church. It could only be by the great southern door, which still exists in the centre of the edifice" Now the door leading from the Well to the church was quite small, inasmuch as Porphyrogenitus informs us that the Patriarch used to accompany the emperor, leaving St. Sophia "as far as the little door leading to the holy well."* But Labarte commits a graver error than this one. The Holy Well was not to the south, but "probably in one of the eastern chapels," as pointed out by Messrs. Lethaby and Swainson. A Byzantine author, quoted by Combefis, says: "In this honoured and celebrated church, there is a coloured eikon of Christ . . . . painted on a panel near the eastern door, where is the well of the Samaritan woman."† There are two doors in the east front, so that we have to examine if the Well was by the northern or southern of the two. This is easy. According to the testimony of a Russian pilgrim, "the stone on which sat Christ, speaking to the woman of Samaria, was in the chapel to the right."‡ Right means south. Meantime, another Russian pilgrim says that this chapel was behind (east of) the Sanctuary.§ Hence we learn:

(*a*) That the door between the Holy Well and the church was small;
(*b*) That the Well was in one of the southern divisions of the eastern annexes; and
(*c*) That it was quite close to the great southern gate, on the east side.

Examining our plan, we find that the first of the eastern chambers, close to the gate, will fulfil all these

FIG. 5.—Entrance of Holy Well, Door of South-east Window, and Corridor of Mannaura. Epoch: 10th Century.

conditions. It will also be seen that the Embolos (portico) of the Well, mentioned by Porphyrogenitus (Fig. 5), is partly still extant, though reconstructed by the Turks,

* *S. Sophia*, p. 78.

† *Ceremonies*, ed. Bonn, Vol. I., p. 182.

* *Ceremonies*, I., ch. 1.

† Du Cange, *S. Sophia*, §76.

‡ Lethaby and Swainson, *S. Sophia*, p. 109.

§ *Ibid*, p. 105.

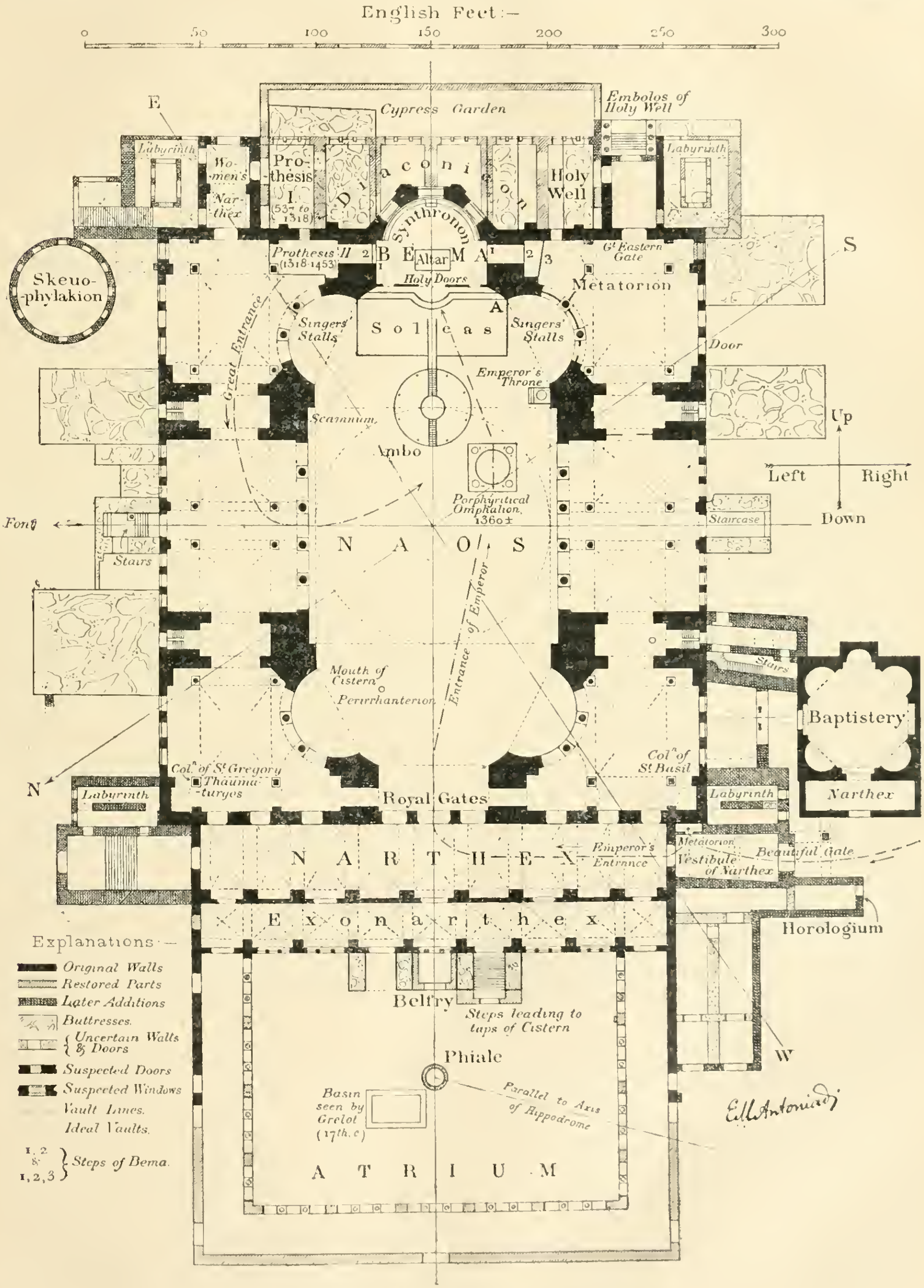


FIG. 4.—General Plan of the Church of the Holy Wisdom, showing the Original Structure, under Justinian, together with all its subsequent known Annexes, up to the year 1453.

probably with a view to raising its columns to a higher level; the mosque being progressively buried in the ground, through the gradual flattening of the adjacent hill of the acropolis.

The Door of the South-East Window.—In addition to the entrance of the Samaritan Well, Fig. 5 shows a door, still preserved, and opened in the great south window of the east front, in the first floor level, or *Catechumena*. On the 14th September, date of the Exaltation of the Cross, the emperor "guided* by the officers of the cubicle and the royal attendants," says Porphyrogenitus, "passes through the Mannaura and its higher corridors, and, having ascended the wooden staircase, enters into the catechumena of the great church."† Inasmuch as no other window of the southern and eastern gallery is pierced by a door, this entrance of the emperor into the Catechumena could have been effected only by the window in question. The wooden stairs probably began at the portico of the Holy Well, being crowned by a little platform just before the door of the first floor level. The idea of a wooden staircase has been shown to have originated in the desire of furnishing to the sovereign an easy escape in case of riot—a means of communication which could easily be destroyed or burned, so as to leave isolated the palace walls.

The Horologion.—This was a very important annex of St. Sophia. Whenever the emperor wanted to go in great ceremony to the cathedral, he used to accord six receptions to various deputations from the city, the last reception taking place by the Horologion of the great church. "And from thence [the Horologion]," says Porphyrogenitus, "the sovereigns enter by the beautiful gate, and have their crowns removed by the præpositi within the curtain hanging in the recess, that is the vestibule of the narthex."‡ On the other hand, the Anonymous speaks of the Baptistery as being "by the Horologion." Now, to fulfil these conditions, the Horologion must have been outside the main entrance, to the south-west, and close to the Baptistery. It can, therefore, be no matter of mere coincidence that, precisely at this spot, at the extreme western angle of the mosque, but facing 34° west of south, the writer has always seen a sundial of Turkish workmanship. Bearing in mind how unchanging everything is in the East, it would not be imprudent to assume that the idea of the Asiatic dial struck its roots in the presence, at this very point, of the sundial erected by Justinus II. and his wife Sophia in the sixth century.

Like Rome, the Mohammedan civilization of Constantinople could not help feeling the influence of Greek art and learning. Neither the difference of race, nor the disparity of manners, nor the contrast of religion could avert a decisive subjugation of the Moslems to the empire of thought bequeathed by the vanquished. The adoption of Byzantine architecture by the Sultans for their religious buildings; the unaltered appearance of the city under the new rule; and the choice, for the national standard, of a Greek emblem, the crescent and star,‡ resting on an astronomical observation twenty-two-and-a-half centuries old, are thus all easily to be accounted for. Imbued with feelings of admiration and reverence for Hellenic genius, the victorious Ottomans soon felt the difficulty of improving upon its masterpieces, and perceived that the real channel for their artistic tastes lay in a close observance of the precepts laid down by the superior science and weightier experience of their enlightened predecessors.

(To be continued.)

* Δηριγευόμενος, from *derigo*.

† *Ceremonies*, I., p. 125.

‡ *Vide* Oman, *The Byzantine Empire*, London, 1892, pp. 4 and 7-8.

ANIMAL WIND-BAGS—USEFUL AND ORNAMENTAL.—III.

WIND-BAGS AS DANGER-SIGNALS AND LIFE-BUOYS.

By W. P. PYCRAFT, A.L.S., F.Z.S., ETC

IN concluding this brief survey of the various types of air-sacs to be met with in the animal kingdom, I propose to deal with those which serve the purpose either of terrifying enemies or transforming their possessors into morsels too large and sometimes too dangerous for prowling carnivores to swallow; and, lastly with those which perform the duties of organs of locomotion. These are, perhaps, the most wonderful and interesting of all, inasmuch as they represent, not parts of, but whole animals, strangely modified for a stranger purpose.

In some cases the whole body is involved in this inflation, whilst in others only certain regions are affected.

The expedient of baffling their would-be devourers by inflating the body with air is a device practised by the globe-fishes of the tropical Atlantic and Indian Oceans. These extraordinary creatures, when hard pressed by some hungry shark, and not too far from the surface, rush up, and thrusting the mouth beyond the water, draw sufficient air into the gullet to inflate the body to such an extent that the fish-like form is exchanged instanter for that of the globe, from which they take their name. This done, they perforce "turn turtle," and float at the surface with the inflated belly well above the water. By this means, like the flotsam of the sea, they are blown along for great distances, the projecting portion of the body catching every breeze that blows, and thus eventually they reach a place of safety. Not always, however, do they escape the fate they flee from, for it occasionally happens that some more than usually greedy shark swallows them, as the sturgeon did Hiawatha. No friendly sea gulls, however, are at hand to effect a rescue, so the globe-fish, left to his own resources, promptly gnaws a hole through the walls of his prison, and, escaping, leaves his misguided enemy a mere lump of carrion. It seems that when too far from the surface to gain the much desired light cargo of air, the globe-fish effects the necessary distension of the body by taking in great gulps of water. Probably only certain forms of globe-fish can be thus swallowed, for it should be mentioned that the skin of some species is armed with enormous bony spines, so numerous as to form a complete investment for the body.

Frogs and toads, when threatened with danger, generally inflate the body. Some common toads, which the writer has had under observation for some months, when alarmed, crouch down, and suddenly blow themselves out till the flanks rise on either side above the level of the back like two great air-cushions. Apparently this increased bulk is intended to act as a danger signal. If this first line of defence is broken through, then they fall back upon the acid secretions of the skin glands, and their effect upon dogs, for example, is well known.

Some species of frogs have acquired extraordinary powers of inflating the body, so that they look more like bladders than frogs. One species, inhabiting the hills of Perak, like the globe-fish, can inflate the body and float on the surface of the water, remaining motionless with arms and legs outstretched. Possibly this habit is a device meant to deceive their enemies, who mistake the inflated body for a decomposing and unsavoury corpse.

The chamæleon, when its safety is threatened, appears to adopt two diametrically opposed methods to ensure its escape. Pacific methods are first attempted. When it perceives itself to be discovered it first attempts to escape

by disguise, making itself as thin and shadowy as possible by compressing its sides, and then, turning itself so that only the thin edge is presented to the enemy. This done, it next endeavours, by a dexterous turn, to place the twig upon which it is resting between itself and the attacking party. By this ruse it often succeeds in effecting the vanishing trick and disappointing its would-be captor. If, however, this plan fails, then the body is as suddenly transformed by inflation. Thus the passive disguise is thrown off and a threatening attitude assumed which is probably generally successful. This inflation is effected partly by inflating the lungs, which have a quite unique structure, inasmuch as they are produced backwards into several blind finger-like sacs which extend far down the body-cavity, and partly by means of a large air-sac in the throat. The purpose of this sac, however, is by no means concerned exclusively with the work of inflating the throat. It probably serves also as a reservoir for air when the entrance to the windpipe is closed by the peculiar mechanism of the tongue in catching insects; and is used also in the production of a peculiar hissing sound which the creature makes when angry.

An agamoid lizard, *Agama sanquinolenta*, common in the deserts of Turkestan, also resorts to the use of a throat-pouch to make itself appear more formidable. The males of this species are very pugnacious, especially during the breeding season. At this time, when about to attack, the throat-sac is inflated till it attains the size of a walnut, the body is raised upon the legs, the head lowered and turned inside, and the foe stealthily watched. Suddenly, with a dart, the attack is delivered, and, if the fates are propitious, the enemy is routed.

Among birds and mammals, as among the frogs and their kind and the reptiles, the practice of magnifying the size of the body, apparently with a desire to terrify their enemies, is also followed. The birds effect this by erecting the feathers, the mammals by causing the hair to stand on end. Certain of the latter, however, have developed special storm signals. The bladder-nosed and elephant seals have been conspicuously successful in this. The latter is so-called from the snout which is produced into a short trunk, flaccid while the animal is quiet, but capable of being inflated and erected when enraged. The wind is forced in through the roof of the mouth. The old sealers, it is said, used to regard the trunk of the elephant seals they killed as a great delicacy, calling them "snotters." The inflatable headgear of the bladder-nosed seal is no less remarkable than that of its brother of the elephantine nose. Indeed, the two structures are really not very dissimilar; for did the inflatable tissue of the first-named extend forward somewhat further a proboscis precisely similar to that of the elephant seal would result. As large as the rest of the head when fully inflated, this peculiar casque is a purely secondary sexual character, being found only in the males. It seems to be used as a signal of defiance, being raised whenever its owner proposes to give battle to such neighbours as may desire to while away the tedium of doing nothing by a friendly bout with the teeth. At such times a quivering motion is given to this curious casque, and this undoubtedly adds not a little to the effectiveness of its appearance.

The Gavial, one of the Crocodilia, is the only one of all the reptiles which has developed a similar bladder-like structure. In the full-grown male of this species (*Gavialis gangeticus*) the nostrils are seated in the middle of a prominent hump. At the will of the animal this can be inflated like a bag. The recoil of the air down the long nasal passages, consequent on the inflation of this bag, has produced a curious modification of certain bones of the skull, resulting in the formation of a pair of hollow globular swellings of the size of a goose's egg. So little is known about the habits of this creature, in spite of the fact that it is common enough in many of the rivers of India, that the occasions when this bag is used, as well as its exact purpose, has yet to be discovered. Possibly, however, it serves the same purpose as that in the seals just described.

These curious nasal wind-bags are, in all cases, in connection with the nostrils through which they are filled and emptied. This fact recalls the existence of certain

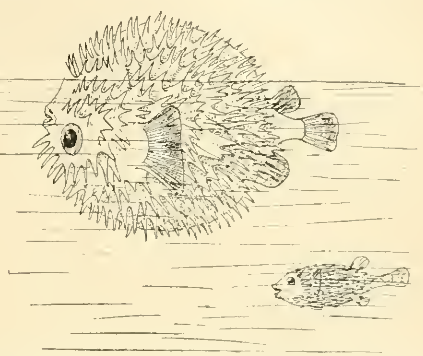


Fig. 1.—The Spotted Globe-Fish, *Diodon maculatus*. The upper figure shows the animal when inflated, floating back downwards, that in the right corner the normal condition.

mysterious air-pouches in connection with the nasal passages, which occur in the horse and the ass, and their relations to the rhinoceros and the tapir. Familiar enough, in the horse at least, to the comparative anatomist and the veterinary surgeon, to whom these structures are known as the "false nostrils," to the general reader their existence is probably quite unknown. Let those who have the opportunity examine carefully the margin of the upper part of the nostril of the horse, when they will find the aperture to what is really a blind pouch, from three to four inches deep, conical in form, and lined with the same smooth skin as that which lines the nasal passage. In the tapir a similar but much more developed pouch is found. In this animal it runs upwards as a narrow tube, at first in conjunction with its fellow of the opposite side, and later separating, each taking a curiously curved or convoluted course, and ultimately terminating in a blind dilatation lodged in a distant groove in the skull bones roofing the snout. In the rhinoceros a similar structure is found, but intermediate in shape between that of the horse and tapir. The "false nostril" of the ass, it should be remarked, is larger than that of the horse.

What the purpose of the pouches in these animals may be is at present a mystery, but they probably are remnants of a once useful structure.

The number of creatures which have adopted the device of imprisoning air, and the variety of uses to which it has been put is indeed striking. So far our survey of this subject has been confined to the higher animals only. Let us now briefly review some of the more striking cases which are to be found among the more lowly animals.

Perhaps the most striking examples to be discovered among these more humble creatures are those furnished by certain jelly-fish which live in colonies and drift about the surface of the open sea, suspended by living life-buoys. In the form known as *Physophora*, for example, an enormously elongated individual undertakes the work of

transporting his fellows, which number some thousands. To conveniently bear this burden, the body of this second "Atlas" is drawn out into a long stalk-like stem, and around this the various units of the colony are grouped; whilst the upper end of this stalk is dilated to form a large and somewhat pear-shaped bag which, filled with air, forms the float or life-buoy. Immediately below the float come what we may call the motor members of the colony. These are bell-shaped, and by alternately opening and closing, draw in and expel the water from their cavities and thus propel the whole colony through the water. These motorists, like the central member which supports the whole, take no food, neither part in the production of the young; they have relegated these duties to other and specially qualified members. The capture and preparation of the food is undertaken by peculiarly modified members found beneath the swimming members. Scattered among the motorists are found numberless small oval individuals, each with a long slender thread. These threads are extremely sensitive, and by their means the members bearing them are enabled to undertake the duties of feeling and exploring for the colony. Lastly, there are the

Fig. 2.—*Physalia*, the "Portuguese Man-o'-War," floating on the surface of the water.

individuals whose sole duty is to provide for the perpetuation of the species. And all these, as we have before remarked, are borne by a single member designed by the Fates, for the sake of the colony, to become a wind-bag.

The wonderful and dread "Portuguese man-o'-war" of the blue waters of the Mediterranean also proves, when examined, to be really a floating colony similar to that of *Physophora*. But the float or life-buoy in this case is much larger, taking the form of a pear-shaped bladder provided with a many-chambered crest or comb. If its duties are of the menial order, it has at least compensation therefor, inasmuch as it shimmers in the sunlight with the most gorgeous colouring, looking like molten silver tinted with light blue, violet, and purple, whilst the small thickenings in the comb are made conspicuous by vivid carmine. The long feelers may measure as much as 50 feet in length, and are vested with a stinging power which makes this creature more dreaded by the native than the shark.

Finally, we may mention certain Mollusca which have adopted the air-float for the purpose of supporting the eggs. Thus the beautiful oceanic violet sea-snail, Ianthina, throws out a long raft containing the eggs, which are carried along the surface of the water, where they may catch the sun and air. It is to be noted, however, that this float differs materially from those of all the others which we have examined, inasmuch as it is made by imprisoning bubbles of air in a gelatinous secretion, and not by the inflation of a pouch or wind-bag.

GIANT LAND-TORTOISES.

By R. Lydekker.

In the long-past days when the plains of India were the home of the mighty sivatherium and of still more gigantic elephants and mastodons, while its rivers were tenanted by hippopotamuses and huge long-snouted, gavial-like crocodiles, that country was likewise inhabited by the most gigantic land-tortoise of which we at present have any knowledge. When fragments of its fossilised shell and more or less nearly complete specimens of its limb-bone came under the notice of its original describers, it was thought, indeed, that they indicated a creature of truly colossal proportions, the length of the shell in a straight line being estimated at no less than twelve feet three inches. In a restoration of the shell made under the superintendence of the discoverers of the species, and still exhibited in the geological department of the Natural History Museum, the length was reduced to a little over eight feet. But even these reduced dimensions appear to be considerably in excess of the reality, and it is probable that the maximum length did not much exceed six feet. A shell of this size vastly exceeds, however, that of any modern land-tortoise, so that the Siwalik tortoise, or *Testudo atlas*, as it is scientifically called, is fully entitled to rank as the real giant of its kind.

But the Siwalik tortoise was by no means the only giant species inhabiting India during the Pliocene epoch, as remains of other, although smaller, forms have been discovered in the same deposits. The nearest living ally of the Siwalik species appears to be *Testudo emys*, of the countries east of the Bay of Bengal, in which the shell does not much exceed a foot in length. Both kinds have the front end of the lower shell produced and notched, although the production and notching are much more pronounced in the extinct form. Both also have the horny shield immediately above the tail double, instead of (as is usually the case) single; and in both the skin of the legs contained embedded nodules of bone.

The Pliocene deposits of the south of France have also yielded remains of a giant land-tortoise (*T. perpiniana*), with a shell about four feet in length, and likewise furnished with bony nodules in the skin of the limbs. And from the caves of Malta have been obtained bones of yet another very large species (*T. robusta*), apparently allied to the recently extinct *T. inepta* of Mauritius.

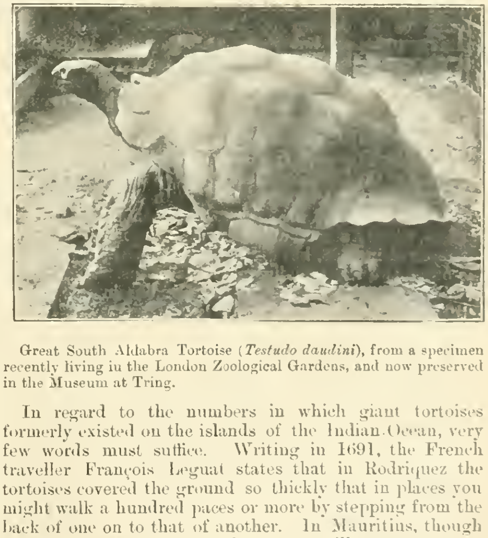
Going further afield, we find evidence of the existence

during late Tertiary times of giant land-tortoises in North America, while a few fragments of shell attest the former occurrence of another species in Patagonia. It may be therefore assumed that during the Pliocene, and, perhaps, a portion of the Miocene epoch, land-tortoises of huge size were spread over the greater portion of the warmer countries of the globe.

With, or before, the close of the Pliocene division of geological time, these great reptiles seem, however, to have utterly vanished from all the continents of the world, and to have continued to exist only in certain islands, from some of which they likewise disappeared before, or during the early portion of, the historic period, while others have become extinct quite recently. Whether these island giant tortoises are the direct descendants of the species which once inhabited the nearest continents, or whether they have been independently developed from smaller forms in or near their own habitats, is a question by no means easy to answer. Neither is it any less difficult to account for the complete disappearance (apparently without human intervention) of all the continental forms. Although the Siwalik mastodons, elephants, sivatheres, giraffes, hippopotamuses, and other large mammals, all died off, yet many of them left descendants (collateral or direct) in either India or Africa; and this makes it the more strange that not a single descendant of any of the Pliocene giant land-tortoises should have survived in any one of the five continents. Such, however, is the case, explain it how we may.

Since the Pliocene epoch, giant tortoises have been restricted to two widely-sundered groups of islands. In modern times the islands most famous for these tortoises are those of the Galapagos group, which take their title from one of the Spanish names (*galápago*) for a tortoise, and are situated on the equator, a comparatively short distance off the western coast of South America. All the other "tortoise-islands" are in the Indian Ocean, where they lie (with the exception of the lower extremity of Madagascar) within the southern tropic, off the African coast. By far the largest of these islands is Madagascar, which has long been inhabited by man, and from which the tortoises (perhaps in consequence of his occupation) disappeared long before the historic period, being known to us only by their sub-fossilised remains. Between the northern point of Madagascar and Africa lie the islands of the Comoro group, which had also native inhabitants of their own; and from these islands the tortoises likewise disappeared at an early date. All the other tortoise-islands in the Indian Ocean were inhabited. They include the Aldabra group, north-west of Madagascar, where the few tortoises now remaining in the south island are under Government protection, the Mascarenhas, or Mascarene group (Réunion, or Bourbon, Mauritius, and Rodriquez), the Amirantes, and the Seychelles. None of the Mascarene species survive in their proper home, and were long thought to be extinct, although a specimen has turned up from a distant island, to which it had been carried. Much the same may be said with regard to the Seychelle tortoises, which were exterminated long ago in their proper habitat. There seems, however, to be good reason for believing that a few survivors of the species have been preserved in islands to which they had been transported in ships. This transportation of tortoises from one island to another has indeed added considerably to the difficulty of unravelling the complicated history of the group; a specimen of the South Aldabra tortoise having been carried to one of the islands of the Chagos group, to the south of Maldives, whence it was subsequently transported to Mauritius.

The accounts left by the early voyagers show that in the Mascarene and other islands of the Indian Ocean, as well as in those of the Galapagos group, the tortoises formerly existed in enormous numbers. As regards the Galapagos islands, it is remarkable that there are no small-sized species; and the same holds good for the islands of the Indian Ocean, with the exception of Madagascar, where there is one comparatively small form (*T. radiata*). It should be added that, if we except Madagascar (where there is one moderate-sized carnivore), none of the tortoise-islands were ever the home of large and predatory mammals. This naturally suggests the idea that the survival in these islands of the reptiles under consideration is entirely due to the absence of such mammals. But, on the other hand, it has to be borne in mind that the giant Siwalik tortoise lived in a land where large mammals—both carnivorous and herbivorous—absolutely swarmed; and the same was also the case with the other extinct continental species referred to above. Moreover, we have no evidence of the existence of large tortoises on the continents of the world at an epoch before the advent of large mammals. Still, the absence of the latter from practically all the tortoise-islands is a fact that cannot be disregarded, and must almost certainly have had a very great influence on the development of their chelonian inhabitants.



Great South Aldabra Tortoise (*Testudo daudini*), from a specimen recently living in the London Zoological Gardens, and now preserved in the Museum at Tring.

In regard to the numbers in which giant tortoises formerly existed on the islands of the Indian Ocean, very few words must suffice. Writing in 1691, the French traveller François Leguat states that in Rodriquez the tortoises covered the ground so thickly that in places you might walk a hundred paces or more by stepping from the back of one on to that of another. In Mauritius, though apparently less abundant, they were still very numerous down to 1740; and there is ample testimony that during the seventeenth and eighteenth centuries they also swarmed on Réunion, although not a single specimen of the species indigenous to that island has been preserved. The ease with which these reptiles could be captured and carried off, and the facility with which they could be kept alive on board, coupled with the large amount of excellent meat yielded by each, rendered them a valuable food-supply to the crews of ships, and it was far from uncommon for vessels leaving Mauritius to carry off a cargo of four hundred at a time, while in 1759 one of four vessels specially engaged in carrying tortoises from Rodriquez to Mauritius took six thousand at once. Such a drain could not but tell rapidly on the supply, and by the early part of the last century the Mascarenes were denuded of their tortoise-fauna.

The Malagasy tortoise (*Testudo grandidieri*) appears, as already said, to have been exterminated before Europeans had any knowledge of the islands, but beautifully preserved shells (wanting the horny shields) have been discovered, three of which are exhibited in the Natural History Museum. Among the Mascarene tortoises, most of which are distinguished from those of Aldabra by their long thick necks and the absence of a nuchal shield * to the shell, five or six species are known in a sub-fossil state from Mauritius. To one of these (*T. indica*) special interest attaches from the circumstance that till about 1871 all the tortoises from the islands of the Indian Ocean were referred to by that name. Of equal interest, although from a totally different point of view, is the Rodriquez tortoise (*T. vosmœri*), on account of the extreme tenuity of its bony shell; a feature shared by certain of the Galapagos species, and indicative that the thick shell characteristic of tortoises generally is not required by the island forms which have no enemies.

A tortoise received in company with two others from the Seychelles in 1894 by Mr. Rothschild, and now living at Tring, is believed to be one of the Mascarene species, with which it agrees in the characters referred to above. It may have come from one of the smaller islands, and thus be different from any of the named forms, although it is difficult to determine this during its life. Very little appears to be known of the Réunion, Comoro, and Amirante tortoises, but it is stated by Mr. Rothschild that the one from Réunion differed from all the other Mascarene forms, and resembled those from Aldabra. Special interest attaches to the history of the surviving representatives of the presumed Seychelle tortoise, which has been named *T. sumeirei*. It appears that in the year 1766 five giant tortoises from the Seychelles were taken to Mauritius by the Chevalier Marion de Fresne, and have been since known as Marion's tortoises. In 1833 one, which died soon after, was brought to the London Zoological Gardens, where a second arrived some years later. A third was received in 1898, but did not long survive its journey. The other two are still living in Mauritius. By far the most celebrated of these latter is the one in the Royal Artillery Barracks at Port Louis. It is now nearly blind, although otherwise in good health. The shell measures about 40 inches in a straight line, and is reported to have been of that size so long ago as 1810. Probably this tortoise was at least a century old when first brought to Mauritius nearly 140 years ago. In its long thick neck, and the absence of a nuchal shield, *Testudo sumeirei* agrees with the Mascarene species, and as it is quite different from the Aldabra forms, Mr. Rothschild considers that its original home was the Seychelles, whence Marion brought his specimens—probably some of the last survivors of their kind—to Mauritius as curiosities. Possibly the tortoise brought in 1798 from the Seychelles to Colombo, where it survived till 1897, may have been of the same species. The length of its shell is 53½ inches, or only an inch-and-a-half less than that of the great South Aldabra tortoise noticed below.

Passing on to the Aldabra tortoises, distinguished by their short necks and the presence of a nuchal shield, we have first to notice that the only member of the group surviving in a wild state in its native habitat is the South Aldabra *Testudo daudini*. Very remarkable is the history of a male of this species received by Mr. Rothschild in 1897, which is the largest known example of modern giant tortoises, the length of the carapace in a straight line being no less than 55 inches, or only 19 inches short of the length assigned to that of the extinct *T. atlas*. This monster, whose original home was South Aldabra, lived for many years on Egmont Island, in the Chagos group, whence it was taken by its owner, Monsieur L. Antelme, to Mauritius, and thence sent to England. It is currently reported to have lived in Egmont for a century and a half, but since the Chagos group was only colonised from Mauritius in the early part of the last century, there is some doubt as to the correctness of the statement. Anyway, this tortoise must have been of a prodigious age at the time of its death. During its sojourn on Egmont Island this tortoise used to bury itself and become dormant for half the year—a most remarkable fact in a tropical island. South Aldabra is a coral island very difficult to traverse, so that it is no easy matter to obtain a sight of the tortoises. Seven were, however, captured and exported in 1895, of which six reached Europe alive.

The second species of Aldabra tortoise *(T. gigantea)* formerly inhabited the north and central islands in great abundance, but is now known solely by individuals introduced by the planters into the Seychelles, where they are kept in a state of semi-domestication, and by a single specimen in St. Helena. There appear to be two races of this species, namely the typical form, in which the shell is depressed, with the horny shields nearly smooth, and *T. gigantea elephantina*, in which the shell is highly convex, with the shields on the back marked by conspicuous concentric striations. In some instances the shield immediately above the tail is divided, as in the extinct Siwalik tortoise. The shell of a male of this species received by Mr. Rothschild in 1893 measured 40¾ inches in length (in a straight line) four years later. The St. Helena example is said to have lived in that island for more than a century. It is not a little remarkable that the survivors of the North Aldabra tortoise should have been preserved in the Seychelles, while those of the species believed to be indigenous to the latter islands have been kept in captivity in Mauritius.

In 1894, Mr. Rothschild's specimen of the North Aldabra tortoise weighed 327 lbs., but by 1897 its weight had increased to 358 lbs. These weights are, however, vastly exceeded by that of the great South Aldabra tortoise which scaled no less than 560 lbs.; this was, however, immediately after its journey to England, during which it had become much emaciated, so that these figures afford no real criterion of its proper weight. Of the habits of the North Aldabra tortoise at Tring, its owner wrote as follows: "Whenever the temperature is over sixty (60° Fahr.), this tortoise has a fine run of 350 acres of grass park, but on the temperature falling to sixty, it is kept in a shed, and when once the temperature shows permanently below 58° Fahr., it is put in an orchid house, *i.e.*, from September to June. When at liberty in the park it lives entirely on grass, but in the hot-house feeds on carrots, cabbages, lettuce, and several other vegetables. It is very fond of rotten fruit."

Of the habits of the giant tortoises of the islands of the Indian Ocean in a state of nature we know practically nothing, owing to the fact that in South Aldabra alone are any members of the group living in a wild condition, and that accurate observation is there practically impossible. Of the mode of life of the Galapagos species we have comparatively full accounts; but limitations of space render it impossible on the present occasion to refer further to these species, either as regards their distinctive characteristics or their history and habits. I have only to add that readers of Knowledge are indebted to Mr. Rothschild for the loan of the photographs illustrating this article.

* The nuchal shield is the single symmetrical horny plate found in the middle line of the front margin of the shell of most tortoises.

THE GREAT MARION'S TORTOISE (*TESTUDO SUMEIREI*).
Now living at Port Louis, Mauritius.

MODERN COSMOGONIES.

By Agnes M. Clerke.

I.—THE NEBULAR HYPOTHESIS.

Immanuel Kant was, in 1751, still in the plastic stage. His period of "Pure Reason" was remote, and might have appeared improbable. Such as they were, his distinctions had been won in the field of concrete science, and the world of phenomena invited his speculations more seductively than the subtleties of logic. A seed was accordingly thrown into fertile soil by his reading of Thomas Wright's "New Theory of the Universe," as summarised in a Hamburg journal. It set him thinking, and his thoughts proved to be of the dynamic order. Wright regarded the heavens under a merely statical aspect. He laid down the first definite plan of their construction, showing that the stars were not aggregated at random, but by method, and this was much for one struggling item of humanity to have accomplished unaided. But the young philosopher of Königsberg could not rest satisfied with the idle contemplation of any subsisting arrangement. His mind was incapable of acquiescing in things simply as they presented themselves; it craved to know further how they came to stand to each other in just such mutual relations. He was, moreover, permeated with Epicurean doctrines. Not in any reprehensible sense. He could not be reproached either as a hedonist or as an atheist. His pleasures were intellectual, his morals austere, his convictions orthodox. Behind the veil of material existence he divined its supreme immaterial Originator, and his perception of the activity in Nature of an ordering First Cause remained equally vivid whether its disclosures were taken to be by immediate creation or through tedious processes of modification and growth. His large and luminous view embraced besides the ethical significance which such processes adumbrate. The following sentence shows an appreciation of the place of man in Nature truer and more profound than was attained perhaps by any other thinker in the eighteenth century:—"The cosmic evolution of Nature," he wrote in memorable words, "is continued in the historic development of humanity, and completed in the moral perfection of the individual."*

Nevertheless, he owned to a community of ideas with Democritus as to the origin of the universe. Lucretius had cast over him the spell of his lofty diction, and captured his scientific adhesion with the stately imagery of his verse. With reservations, however. Docile discipleship was not in his line. He availed himself, then, of the Democritean atoms, but by no means admitted their concourse to be fortuitous. Chaos itself, as he conceived it, half concealed, half revealed, the rough draft of a "perfect plan." His postulates were few. He demanded only a limitless waste of primordial matter, animated by no forces save those of gravitation and molecular repulsion, and undertook to produce from it a workable solar system. The attempt was no more than partially successful. Indeed, investigations thrown back into the fore-time lead, at the best, to precarious results, and this one, in particular, was vitiated by a fundamental error of principle. Its author clearly perceived that planetary circulation must be the outcome of a vortical swirl in the nebulous matrix; but he failed to see that no interaction of its constituent particles could have set this swirl going. Systems cannot, of themselves, add to their moment of momentum. External force should be applied to originate rotation in those naturally destitute of it. Now Kant was averse to employing arbitrary expedients, and he piqued himself on the simplicity of his postulates. Yet he need not have hesitated, had he only viewed things from the modern standpoint, to impart a wheeling movement to his colossal dust-cloud, as the upshot of the mode in which its materials might have come together from the four quarters of the universe; and he would thus have escaped stumbling at the threshold of his daring enquiry.

He supposed the particles forming the initial inchoate mass to fall together by gravity, but to be deviated from rectilinear courses through the effects of unequal resistance. And he derived from the combination of these multitudinous encounters a common axial rotation for the entire agglomeration. The futility, however, of this mode of procedure was adverted to by the late M. Faye in 1885.* The deviations in question would, in fact, exactly balance one another, there being no reason why movement in one sense should prevail over movement in the opposite: consequently, a general rotatory movement could not even begin to affect the seething mass, which would condense in sterile rigidity. Kant should then, as Laplace did, when his turn came, have assumed the gyration indispensable to his purpose. He asked too little from Nature; nor is the modesty of a demand other than a poor excuse for failure due to inadequacy of supply.

Kant made the germ of the future sun to consist in an aggregation of atoms at the core of the nebula, which, growing by successive, innumerable accretions, provided the motive power for the machinery of planetary construction. For it was, as we have seen, the jostling of the particles drawn towards the gradually preponderating centre of attraction which set on foot, it was supposed, the whirl eventually transformed into the tangential velocities of the sun's attendant bodies. They were formed, like the sun, by the perpetuation and increase of subordinate nuclei sure to arise in the elemental tumult. They were formed, not under the guidance of a definite law, but just where chance —or what seemed like chance—favoured an accretion. Nor could they have had a direct rotation.† Under the given conditions retrograde systems should have originated. This would have necessarily ensued from the incoherence of their materials. Particles revolving independently one of the others have smaller velocities the more remote they are from the focus of movement. Should they agglomerate into a globe, the inner ranges must, as being the swiftest, determine the direction of its rotation, which will consequently reverse the direction of its orbital revolution. Hence, it depends upon the nature of their generating stuff no less than upon the advance of central condensation, whether planets, in their domestic arrangements, contravene or obey the larger law of circulation prevailing in the system to which they belong; and Kant's nebula was undoubtedly such as to involve its contravention.

Yet his scheme, with all its deficiencies, bore the authentic stamp of genius—of genius imperfectly equipped with knowledge, but original, penetrative, divinatory. The very entitling of the work "A Natural History of the Heavens" was an audacity implying a radical change of conception. It was here that "island-universes" made their definitive appearance. Wright had indeed, five years previously (in 1750) thrown out the idea that "cloudy spots" might represent "external creations"; but as a mere vagary of the scientific imagination. Kant unhesitatingly laid hold of it; classed nebulæ as so many separate galaxies, and regarded them as combining with our own into a revolving system on a surpassing scale of grandeur. Kant was also the first to take into account

* Quoted by Dr. Hastie in the preface to his translation of Kant's "Cosmogony," Glasgow, 1900.

* "Sur l'Origine du Monde," 3e éd., p. 136.

† This also was pointed out by M. Faye, *loc. cit.*, p. 150.

the effects on their development of the plasticity of the heavenly bodies. He published in 1754, in a Königsberg paper, by way of preliminary to his forthcoming "Natural History," an outline of the workings of tidal friction in the earth-moon system. He saw clearly that it had acted in the past to reduce our satellite's rotation to its present minimum rate; and that it even now, by very slow degrees, tended to retard the spinning of the earth. This brilliant intuition remained unnoticed for well-nigh a century.

The assertion, however, that Kant's Cosmogony was an anticipatory "Meteoritic Hypothesis" lacks foundation. It is only true in the sense that his building-materials were pulverulent, not "fluid." Laplace's primitive nebula was a coherent mass. It rotated as a whole; it divided only under considerable strain; its separated parts showed concentrative power and individual unity. Kant's elemental matter, on the contrary, was a loose aggregate of independent particles, each pursuing its way, disturbed indeed by its neighbours, but essentially isolated from them. They were, in short, genuine Lucretian atoms, intended to stand for the ultimates of Nature, so far as such obscure entities could be evoked by fancy. The chaos that they formed was in nowise a "meteoritic plenum," unless the phrase be emptied of all distinctive meaning. Meteorites, so far from being primordial units, have the show and semblance of advanced cosmical products. They raise special questions in chemistry, mineralogy, geology, and physics, claiming to be dealt with by experts in each branch. Before serving for explanatory purposes, in fact, they themselves need to be explained.

Laplace enounced his Hypothesis in 1796, and republished it with supplementary details in 1808. Herschel had meanwhile ascertained the retrograde movement of the Uranian satellite-system, a circumstance highly damaging to the validity of the adopted line of reasoning; yet its author was content to leave it in jeopardy. He must, to be sure, have regretted that Nature had seen fit to mar the admirable symmetry indicative of her presumed plan of action, running counter thereby to the plainest teachings of the doctrine of probabilities. But he kept his own counsel on the subject, preferring that it should be discussed, as it has been, by posterity; and posterity has, at any rate, learned that the seeming caprices of Nature are often more instructive than her most harmonious regularity, and has derived a warning from her frequent breaches of continuity against the undue extension of apparently well-grounded inferences.

Nevertheless, the constructive scheme handed on by the eighteenth to the nineteenth century has not, so far, been consigned to the Limbo of Vanities. It accorded too profoundly with undoubted realities to be thus summarily disposed of. No one then living had studied the mechanism of the solar system so attentively, or was so intimately acquainted with its workings, as Pierre Simon Laplace. None knew better how admirable, yet how far from inevitable were the adjustments by which its stability was secured. Long meditation upon their poise and plan persuaded him that the subsisting congruities of arrangement must have had their source in community of origin. He thus acquired the settled conviction that the sun engendered his cortège, or was together with it engendered from one parent-mass. And this virtually new truth (for Kant's speculation had attracted the minimum of notice) was set forth by him with a directness and lucidity which won for it an immediate place among the permanent acquisitions of the human intellect. Few perhaps any longer believe that planetary formation took the precise course laid down for it in the "Système du Monde"; but fewer still doubt that the entire ambit of the solar system was once occupied by an inchoate sun, and that its component bodies came into being incidentally to that sun's progressive contraction. In favour of this view Laplace could allege no clinching argument; it recommended itself to him solely through its inherent probability. Unexpected confirmation has, however, been afforded to it by the modern theorem of the conservation of energy, applied by Helmholtz with widely illuminative effect to solve the problem of the maintenance of solar heat. Laplace assumed an enormously high initial temperature. It was the only way open to him, and he took it. But a transcendentally hot nebula is not easily conceivable; an exalted thermal state seems, and probably is, incompatible with a high degree of attenuation. The key to the enigma was given by the demonstration that a diffuse mass, although actually cold, might contain vast stores of potential heat. There was then no need to postulate a primitive "fire-mist"; the surrendered energy of position amply sufficed to meet the requirements of the case. The temperature of the nebula necessarily rose as it contracted through gravitational stress; shrinkage and heat-evolution proceeded together; and they proceed together still. We live by the collapse of the sun. If its particles ceased to descend, their incandescence would quickly fail, and terrestrial vitality would become extinct.

Their number, however, being finite, the store of energy they can supply in falling, even from an infinite distance, is also finite. The process of solar sustentation is then terminable; it had a beginning, and it will assuredly come to an end. Now the *terminus ad quem* is of a calculable remoteness; it can be located within certain limits of time. But the *terminus à quo* depends upon too many conditions to be satisfactorily defined It is only certain that the sun is to-day slightly more condensed than it was a year ago. It might, a few millenniums back, have been measurably larger, had modern micrometrical methods been available in the Stone Age; while, looking into the geological past, we discern a continually more diffuse globe, filling the orbit of Mercury when the earth was perhaps still red-hot, then successively ampler spheres, out to, and beyond that of Neptune. And here we are confronted with Laplace's nebula. The state of things he imagined results, accordingly, from two opposite modes of enquiry, by tracing forward the development of a tenuous rotating mass, and by pursuing backward the surely indicated, unceasing and inevitable distension of the sun. Hence, no sooner was it acknowledged that energy may be transformed, but cannot be destroyed, than the Nebular Cosmogony assumed a new and authoritative aspect.

Its scope, during the interim, had prodigiously widened. Five years before its promulgation at Paris, Herschel gave at Slough the first hint of a corresponding scheme of sidereal evolution. The discovery of a nebulous star in Taurus (N.G.C. 1514) set him pondering; and he found himself, as the upshot of his meditations, reduced to the dilemma either of concluding nucleus and *chevelure* to be alike stellar, though composed of stars differing enormously in real magnitude, or of admitting the possession by the star of a voluminous appendage constituted of a peculiar and unknown "shining fluid." He chose the latter alternative, adding the pregnant remark: "The shining fluid might exist independently of stars," and "seems more fit to produce a star by its condensation than to depend on the star for its existence." *

Thus tentatively, and under the compulsion of phenomena, rather than by the deliberate choice of its inventor, the universal theory of the genesis of stars from nebulæ took its rise. Herschel shaped it definitively in 1811 and 1814

* *Phil. Trans.*, Vol. LXXXI., p. 85.

into a formal rationale of celestial appearances, but in a large and general way. He made no attempt to realise the particularities of a process vaguely conceived of as one of growth by absorption or assimilation. He and Laplace thought out their separate schemes quite irrespectively one of the other. There is no evidence of their having met or corresponded, nor does their mutual influence appear to have been appreciable. Yet Laplace needed, as the raw material for his solar system, precisely the "shining fluid" elaborated, one might say, by Herschel, partly through the revelations of his telescopes, partly as the outcome of his reasonings concerning the *chevelure* of the star in Taurus. Halley, it is true, had by a sagacious intuition surmised the composition of nebulæ out of a "lucid medium." But the ineffectual phrase remained stranded in the pages of the *Philosophical Transactions*, and has only of late been set floating on the stream of scientific literature. Down to the end of the eighteenth century, world-building had been a purely speculative undertaking. It lacked actuality; it was concerned with operations thought of as belonging exclusively to a past order of things, now over and done with, and lying wholly outside the range of experience. Through Herschel's synthesis, however, those dimly apprehended operations were brought into view as variously progressing even now in different parts of the Cosmos, as incipient in some regions, advanced in others, the rubbish of the workshop here half masking the rising edifice, while elsewhere signs of decay and exhaustion give legible presage of an appointed end. And this stupendous vision of a forming universe has not vanished on critical scrutiny. It is no dream-tissue; it cannot dissolve into airy nothingness; it is based upon a firm substratum of reality. The immeasurable purposes of Creative Wisdom are still only in part fulfilled. It has become the strange privilege of humanity to contemplate, from its little shoal of time, the oceanic flow of their development. Thus, in the swing of the ages, Laplace's thought was caught up and vitalised. He himself was scarcely sensible of their movement. He recognised very imperfectly, if at all, his obligations to Herschel's nebulous star. His means were inadequate; his field of view narrow; his knowledge, though co-extensive with that of his time, fell short of what his boundless task demanded. In some respects his mode of procedure was faulty; his forecasts have been belied; the behaviour imputed by him to a nebula such as he devised is questionable, if not impossible. But, with the instinct of genius, he hit off the "psychological moment"; and, divining the genetic import of harmonies of construction obvious to perception, but arduous of interpretation, he laid down with masterly simplicity the ground-plan of a structure likely to maintain its substantial integrity despite innumerable additions and modifications.

THE PATH OF THE MOON.—II.

By A. C. D. Crommelin.

We now pass on to the second part of the subject—viz., the more accurate study of the shape of the Moon's path round the Earth. If we suppose her to have been so projected as to describe a circle round the Earth in the plane of the ecliptic, then the Sun's disturbing action would distort this circle into an oval with its shorter axis in the direction of the Sun and its longer one at right angles to this direction. The diameters of the oval are as 69 to 70, which implies that the Moon is on the average 3400 miles nearer at syzygies (New or Full) than at quadrature. We can verify this by taking the Moon's Parallax at the 4 quarters for the "Nautical Almanac" for several years and taking the average value of each. Thus for the nine years 1883—1891 the average parallaxes are as follow—

New Moon 57′·62, Full Moon 57′·65, First and Last Quarter 56′·81.

This oval is known as the Variation curve, and in the researches on the Moon's motion commenced by Prof. Hill, and now being continued by Prof. E. W. Brown, it is taken as the starting point on which all the other disturbances are superposed. This method promises to give at once greater facility and greater accuracy in the study of the Moon's motion.

It will be noticed that the New Moon is slightly further away (about 120 miles) than the Full Moon. It is also found that the time from Last Quarter to First Quarter is (on the average of a large number of lunations) a quarter of an hour longer than that from First Quarter to Last Quarter. These are known as the Parallactic Inequalities in the Moon's distance and longitude, since they depend on the Sun's distance, and would disappear if this were sensibly infinite compared with the Moon's. The inequality in longitude can be determined observationally by observations near the First and Last Quarters, extending over many years, and the Sun's distance can be deduced from the result. Prof. Hansen, in this way, found that Encke's value of the Sun's distance ($95\frac{1}{3}$ millions of

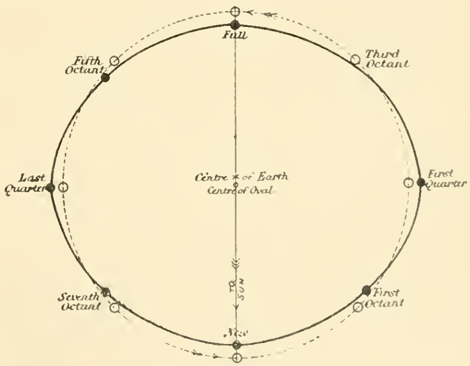


Fig 3.—The Variation Oval.

○ = Mean Moon. ● = Moon affected by variation.

miles) was too great. Hansen, however, reduced it too much, his value being about $91\frac{1}{4}$ millions, instead of the now accepted value of 93 millions. The diagram (Fig. 3) gives an idea of the shape of the Variation curve; the departure from circularity, as also the slight displacement of the Earth from the centre of the oval, are very greatly exaggerated. The white circles indicate the position of the Mean Moon, while the black ones indicate that of the Moon affected by the Variation. If we leave the Parallactic Inequality out of consideration we see that the effect of the Variation on her direction vanishes at all 4 quarters, and reaches a maximum at the intermediate points or octants, where it amounts to $39\frac{1}{2}'$. At the first and fifth octant the Moon is in advance of the Mean Moon by this amount, while at the third and seventh it is the same amount behind it.

The ancient astronomers trusted chiefly to eclipses for

the determination of the Moon's place, and consequently did not detect the Variation since the latter vanishes (as regards her direction) at both New and Full Moons.

The undisturbed path of the Moon round the Earth is not, however, a circle, but an ellipse with eccentricity $\frac{1}{18}$.

This produces the elliptic inequalities in her distance and direction. At perigee and apogee her direction is the same as that of the Mean Moon, but her distance is 13,200 miles less or greater than the mean distance, 238,818 miles. One quarter of a revolution after perigee she is at her mean distance, but $6^\circ\ 16\frac{1}{4}'$ in advance of the Mean Moon, while one quarter of a revolution before perigee she is an equal amount behind it.

The first effect of the Sun's action on this elliptic motion is to make the perigee move round the Earth in a period of 8·85 years, so that an anomalistic month (from perigee to perigee) is slightly longer than a sidereal one. But in addition to this continuous effect there is a periodic effect, known as the Evection, which produces a large oscillation, both in the eccentricity of her orbit and in the direction of her perigee. When perigee occurs at New or Full Moon the eccentricity rises from 0·055 to 0·066, while when perigee occurs at First or Last Quarter it falls to 0·044.

The perigee point has a mean annual motion of $40\frac{2}{3}^\circ$, but the Evection makes its motion oscillatory. At all the four quarters the directions of true and mean perigees coincide. When perigee occurs at the 1st or 5th octant (*vide* the "variation" diagram) the perigee point lags some 25° behind its mean position, while at the 3rd or 7th octant it is an equal amount ahead of it. At these times the eccentricity of the orbit has its mean value 0·055.

Owing to the Earth's orbit round the Sun not being circular, the disturbing action of the Sun on the Moon undergoes an annual variation. This produces the "annual equation" of the Moon's longitude; she is at her mean place about January 1st and July 1st, some 11′ behind it about April 1st, and an equal amount ahead of it about October 1st.

Some readers may be glad to have the means of computing with tolerable accuracy the Moon's longitude, latitude, and parallax for any epoch. Thus questions sometimes arise as to the date of New Moon in some distant year, or the position of the Moon after some battle or other historical event, and one has not always books of reference at hand to give the information. The notation in the following formulæ is that of Delaunay, but the numerical values of l, l', F, D, are due to Newcomb.

We first find the interval in days between the epoch required and 1900, January 1, Greenwich noon. This interval is called n, and is positive when the epoch is after 1900. We next calculate the values of l, l', F, D, from the following formulæ:—

l = Moon's Mean Anomaly = $309^\circ{\cdot}174 + 13^\circ{\cdot}064993\ n$.

l' = Sun's Mean Anomaly = $359^\circ{\cdot}465 + 0^\circ{\cdot}985600\ n$.

F = Moon's Mean Longitude measured from Asc. Node = $24^\circ{\cdot}482 + 13^\circ{\cdot}229351\ n$.

D = Difference of Mean Longitude of Moon and Sun = $2^\circ{\cdot}930 + 12^\circ{\cdot}190750\ n$.

Then the following formula gives us the Moon's Longitude:—

$$\begin{aligned}\text{Longitude} = {} & 283^\circ{\cdot}614 + 13^\circ{\cdot}176395\ n - 0^\circ{\cdot}186 \sin. l' + 6^\circ{\cdot}289 \sin. l \\ & + 0^\circ{\cdot}041 \sin. (l - l') - 0^\circ{\cdot}030 \sin. (l + l') + 0^\circ{\cdot}214 \sin. 2\,l \\ & - 0^\circ{\cdot}114 \sin. 2\,F + 0^\circ{\cdot}658 \sin. 2\,D + 0^\circ{\cdot}046 \sin. (2\,D - l') \\ & + 0^\circ{\cdot}053 \sin. (2\,D + l) + 1^\circ{\cdot}274 \sin. (2\,D - l) + 0^\circ{\cdot}057 \sin. (2\,D - l - l') \\ & + 0^\circ{\cdot}059 \sin. (2\,D - 2\,l) - 0^\circ{\cdot}035 \sin. D.\end{aligned}$$

For the smaller terms a very rough computation of the angles will suffice. The error of the deduced longitude will seldom exceed 3′. For distant epochs we may apply the following correction to the longitude for secular acceleration (taken as 8″ per century).

Years before or after 1900.	Correction to Longitude.	Years before or after 1900.	Correction to Longitude.
200	+ 0·01	1100	+ 0·27
300	+ 0·02	1200	+ 0·32
400	+ 0·04	1300	+ 0·37
500	+ 0·06	1400	+ 0·43
600	+ 0·08	1500	+ 0·50
700	+ 0·11	1600	+ 0·57
800	+ 0·14	1700	+ 0·64
900	+ 0·18	1800	+ 0·72
1000	+ 0·22	1900	+ 0·80

In the above equation the term with argument l' is the "annual equation," that with l the "elliptic inequality" with 2 F the "reduction," with 2 D the "variation," with 2 D $- l$ the "Evection," with D the "Parallactic Inequality."

The Moon's Latitude = $5^\circ{\cdot}128 \sin. F + 0^\circ{\cdot}281 \sin. (F + l) - 0^\circ{\cdot}278 \sin. (F - l) + 0^\circ{\cdot}033 \sin. (2\,D + F) + 0^\circ{\cdot}055 \sin. (2\,D + F - l) + 0^\circ{\cdot}173 \sin. (2\,D - F) + 0^\circ{\cdot}046 \sin. (2\,D - F - l)$.

The formula for the Parallax is very simple; the following expression will give it to within a few seconds of arc:

Parallax = $57'{\cdot}04 + 3'{\cdot}11 \cos. l + 0'{\cdot}17 \cos. 2\,l + 0'{\cdot}47 \cos. 2\,D + 0'{\cdot}57 \cos. (2\,D - l)$.

The semidiameter may be found by taking $\frac{3}{11}$ of the Parallax and then subtracting 1″.

The term in the latitude with argument 2 D − F is strikingly similar to the Evection. It has the effect of making the inclination of her orbit to the ecliptic a maximum (5° 18′) when New Moon or Full Moon occur at a node, while it is a minimum (5° 0′) when First or Last Quarter occurs at a node. Thus the inclination is at a maximum for all eclipses, and in consequence we get rather fewer eclipses than we otherwise should.

The motion of the node is also oscillatory as that of the perigee is, but to a much smaller extent. Thus the True Node coincides with the Mean Node when Nodal passage occurs at any of the 4 quarters; it is retrograding at double the Mean rate when the node is passed at quadrature, while it practically stands still when the node is passed at syzygies.

When the node is passed at the 1st or 5th octant the longitude of the True Node is some 2° less than that of the Mean Node, while at the 3rd or 7th octant it is an equal amount greater than it.

The method of expressing the perturbations as the sums of series of sines and cosines of uniformly varying angles is that which is employed in all the lunar and planetary tables. When such tables have once been constructed, the computation of the place of the Moon or planet at any time is merely a matter of simple arithmetic.

In the above description of the Moon's True path round the Earth, no attempt has been made to explain the reason of the various inequalities; it is not indeed easy to get far in the theory of the subject without the use of analytical methods. But in a difficult problem like the Lunar Theory I believe the best method is to commence with an accurate arithmetical conception of the nature of the Moon's motion, after which theoretical researches can be pursued with much greater interest and facility.

Letter.

[The Editors do not hold themselves responsible for the opinions or statements of correspondents.]

DID THE ROMANS KNOW ALUMINIUM?

TO THE EDITORS OF KNOWLEDGE.

Sirs,—The origin of the legend (*see* Knowledge, September, 1902, p. 203) which may lead us to suppose that the Romans may have known aluminium is to be traced to a passage of Petronius' "Satyricon," Chapter LI., (1) of which the following is a translation :—

"However, a workman succeeded in making a cup of a kind of glass which could not be broken. Admitted to the presence of the Emperor, he presented it to him, then, begging to have it handed back to him, he threw it down on the stone floor. The Emperor could not help shuddering, but the workman picked it up all dented, as would have been the case if made of bronze, took out a small hammer from his pocket, and, without being in the least concerned, thoroughly repaired the damage. After this, he already thought himself on Jupiter's throne, especially when he heard himself being asked: 'Is there any man acquainted with thy process? Think.' 'No one.' The Emperor thereupon ordered his head to be cut off, for if the thing once got to be known, gold and sand would have the same value for us."

Petronius' account was written about A.D. 60. Pliny the Elder (2) (Hist. Naturalis l. XXXVI., c. 26) succinctly records it, perhaps after Petronius, without seeming to give it very much credit. His text dates from A.D. 75.

According to Dion Cassius (3), Roman History (written about A.D. 220) (R.R. lib. LVII., c. 21), the anecdote would be posterior to A.D. 22.

Isidorus of Sevilla (4), who lived in the VIIth century of the Christian era, and who is known especially for his "Etymologies," relates Petronius' account, while somewhat modifying it.

In his book of Etymologies (16th book, chap. 16), the following is in effect to be found :—

"It is said that under the reign of Tiberius a workman had invented a vitreous combination (*vitri temperamentum*) which was flexible and ductile."

He then recounts substantially the same anecdote as that I have quoted from Petronius.

To sum up, the anecdote which may give occasion to suppose that aluminium was known in the time of the Romans must date from about A.D. 25 (according to Dion Cassius) at Rome.

We know it :—

1st. From Petronius' Sat. 51 (about A.D. 60), a picturesque anecdote.

2nd. From Pliny the Elder, H. N. XXXVI., 26 (about A.D. 75), a mere mention.

3rd. From Dion Cassius, H. Rom. 57, 21 (about A.D. 220), a mere mention.

4th. From Isidorus of Sevilla, Etym. XVI., 15, 6 (about A.D. 600), an anecdote similar to that of Petronius.

With the exception of the last of these accounts, it is clearly a question of an "unbreakable glass"; and, in fact, Petronius' anecdote has been attributed to the manufacture of annealed glass.

If we refer to the passage in Petronius, we will notice that the author has put the account into Trymalcion's mouth, following upon another account about the origin of the Corinthian bronze, which is evidently absurd. In fact, Petronius wanted to make Trymalcion appear ridiculous, and his commentators (Panckouke Translation) point out that the legend of ductile glass was a tale of antiquity which no longer found any belief at the beginning of the Christian era

And now we can ask ourselves the question—supposing the anecdote related by Petronius is serious—in what manner could Tiberius' workman have obtained aluminium?

A few years after the discovery of aluminium, a memorandum from M. Chapelle appeared in the Reports of the Academy of Sciences, tending to prove that by heating a mixture of chloride of sodium, clay, and charcoal, a multitude of metallic globules are obtained, which would be aluminium.

Good Isidorus of Sevilla, who after his account gives such an ingenuous note, will not accuse us of being naive if we say that, given its origin, this note may be taken seriously.

In the course of work which has led me to obtain blue glasses with base of chromium, I had occasion to make an interesting experiment. In a paper which the "Berichte der Deutsche Chemische Gesellschaft" (1898) have inserted in its entirety, and to which the "Chemical News" (5) (Vol. 78, No. 2021, 1898) has likewise given ample hospitality, I have published the following experiment :—

I have heated in a fireclay crucible lined with charcoal a mixture of borax and alumina with a small quantity of dichromate of potassium and a quantity of silica equal to a two-fifth part of the alumina used, a metallic pellicle was formed, consisting for the most part of aluminium.

It is well known that boric acid is plentiful in Italy, since for a long time the greatest part of the borax delivered for the purposes of industry came from the lagoons of Tuscany. Therefore, it is not impossible that the three bodies—boric acid, potassium, clay—which under the influence of charcoal, perhaps favoured by small quantities of foreign substances, may give aluminium, might have been brought together.

However, I have not, any more than Tiberius' workman, the pretension of having obtained pure aluminium by this process; but it appears to me interesting to compare this result of an experiment, which interested a few chemists at the time I made it known, with the question raised by your correspondent.

At any rate, the question deserved to be asked, and here the legend is indeed of more worth than many well established truths, since it leads one to make curious experiments; as for me, I am indebted to it for the discovery of the reduction of alumina by aluminium, as well as that of the extraordinarily energetic combustion of a mixture of water and pulverised aluminium, which is set alight by means of a little dry powdered magnesium.

A. Duboin,

Docteur ès-Sciences Physiques, Maître de Conférences à la Faculté des Sciences de Grenoble.

Obituary.

Sir GEORGE STOKES.

By the death on February 1st of Sir George Gabriel Stokes this country lost one of the most eminent men of science that it has ever possessed, and the greatest mathematician of the day.

He was born on August 13th, 1819, at Skreen, Co. Sligo, his parents being the Rev. Gabriel Stokes, the Rector of the parish, and Elizabeth, daughter of the Rev. John Haughton, Rector of Kilrea. When thirteen years of age he was sent to Dublin to be educated at the school of the Rev. R. H. Wahl, D.D., from which he passed in 1835 to Bristol College. At the age of eighteen he entered Pembroke College, Cambridge, where in 1841 he graduated as Senior Wrangler and First Smith's Prizeman. He became Fellow

of his College in the same year, and held the Fellowship until 1857, when he vacated it on his marriage to Mary, daughter of the Rev. T. R. Robinson, D.D., Director of Armagh Observatory. He was reinstated in the Fellowship when the new statutes of the College rendered this possible. He was appointed in 1849 Lucasian Professor of Mathematics in the University of Cambridge, the chair held one hundred and eighty years earlier by Sir Isaac Newton. He was elected Fellow of the Royal Society in 1851, became its Secretary in 1854, and its President from 1885 to 1890. From this Society he received the Rumford and the Copley Medal; the former in 1852 in recognition of his investigations regarding the refrangibility of light, the latter in 1893. In 1869 he presided over the British Association at its meeting in Exeter. He was elected as one of the Members for the University in Parliament from 1887 to 1892, and was created a baronet in 1889.

The above brief list may serve to give some little idea of the honours to which he so deservedly attained. Of the work which he performed it is impossible to give any adequate idea; it can only be fully appreciated by those to whom he had been as intellectual parent. We can, perhaps, best summarize his scientific career and work in the concluding words of an article written by Prof. J. J. Thompson for the *Cambridge Review* of 1899, June 1st, in connection with the celebration of the Jubilee of Sir George Stokes as Lucasian Professor:—"By his researches on hydrodynamics he has founded a new branch of the science; in optics he has, to use the words of Lord Kelvin, been the teacher and guide of his contemporaries; he was the first to enunciate in his lectures the principles on which spectrum analysis is founded; he unravelled the laws of fluorescence; he investigated the variation of gravity over the surface of the earth; he solved problems of the greatest difficulty in pure mathematics; whilst the latest of his long series of researches is his remarkable paper on the nature of Röntgen rays. His papers are the classics of science; they are remarkable, not only for the results obtained, but also for their perfect clearness of expression and thought, for the elegance of the mathematical methods, for their maturity of judgment, and for that care and finish on which so much of the impressiveness of a paper depends.

These researches show the combination of supreme mathematical and experimental power; with simple apparatus and without the appliances which are now at the command of physicists, he has made experiments which have settled some of the most crucial points in optics, and which will be quoted as long as science exists. The rooms in Pembroke, where he made many of his experiments, will in the history of science and of the University be associated with those in the old court of Trinity, where Newton made the prism reveal the nature of white light. And, indeed, there are many points of resemblance between the careers of Newton and of Stokes: both held the Lucasian Professorship, both were Presidents of the Royal Society, both represented the University in Parliament; and the resemblance is not confined to the offices they held, it extends to their type of mind. Often, in reading Stokes's papers, we feel this is just how Newton would have treated this point, these are the deductions which Newton would have drawn."

Notes.

ENTOMOLOGICAL.—Prof. W. N. Wheeler continues his studies of North American ants, that have been previously mentioned in these columns. In the *American Naturalist*, Vol. XXXVI., 1902, pp. 88-100, he describes *Pogonomyrmex imberbiculus*, a new "Agricultural" Ant, from Texas. Incidentally he refutes the popular and widely-diffused notion that some ants of this genus cultivate a particular kind of grass—the "ant rice"—protecting, weeding, and reaping their crops. These ants feed largely on grass seeds, and when some of the seeds that they have brought into their minute storehouses sprout so far as to become unfit for food, the ants carry them out to a kind of rubbish heap, which often forms a circle around their nests. These seeds may then germinate and grow up, forming an imperfect ring of grass, but, as Prof. Wheeler remarks, to state that the ants "sow this cereal for the sake of garnering its grain, is as absurd as to say that the family cook is planting an orchard when some of the peach stones which she has carelessly thrown into the back-yard chance to grow into peach trees."—G. H. C.

GEOGRAPHICAL.—Dr. Carl Lumholtz, who spent five years, between 1890 and 1898, in North-western Mexico, recently read a very interesting paper on his explorations and researches before the Royal Geographical Society (*see* the *Geographical Journal*, February, 1903). Dr. Lumholtz lived for a considerable time alone with various Indian tribes in the western Sierra Madre Dr. Lumholtz's ethnological researches and collections are of great interest and importance. Speaking of the endurance of the members of a tribe called the Tarahumare, the author mentions that these people will easily run one hundred and seventy miles without stopping. They have regular races as a test of endurance rather than speed. As a proof of their insensibility to pain, Dr. Lumholtz once witnessed twenty-three hairs pulled out in one stroke from the head of a sleeping child, who merely scratched its head a little and slept on. Many of the Indians of the Sierra Madre are very musical, and Dr. Lumholtz, who has learned their songs, gave examples of them in the course of his paper. Most of these tribes are deeply religious, and Dr. Lumholtz has studied particularly their symbolism. Every little detail and ornament bears not only a religious significance, but often forms an actual prayer. The author referred to certain species of cacti, which are worshipped by two tribes of Indians, a regular cult being instituted, whose main purpose is to promote the health of the tribe as well as to bring rain. The plant is supposed to talk and sing, and to feel joy and pain. It has great exhilarating properties, and allays all feelings of hunger and thirst, and does away with all exhaustion. It also produces colour-visions. A great feast, elaborate and lengthy preparations for which are made, is held at certain times, at which the plant is eaten. The main feature of the feast is a peculiar kind of dancing by men and women, whose faces are painted with various designs with a symbolic meaning.

ZOOLOGICAL.—The Society for the Protection of Birds held a very successful and well-attended annual meeting on February 10th, under the chairmanship of the Duke of Bedford. During the year 1902 the Society made distinct advances in several directions. A short Bill, framed by the Committee of the Society, was passed through the Houses of Parliament. It provides for the confiscation of any bird unlawfully killed or captured, or any egg unlawfully taken. Formerly the specimens illegally secured were often of more value than the fine imposed. The Society may be congratulated, too, on having been the means of inducing the authorities in British India to prohibit the exportation of bird skins and feathers (except ostrich feathers and *bonâ fide* specimens "illustrative of natural history") from that country. The Society are doing good work, too, in encouraging the young to take an intelligent interest in bird-life.

Our knowledge of the vertebrate zoology of Egypt has been largely augmented by the appearance of the handsome and splendidly illustrated volume on the Mammalia by the late Dr. J. Anderson and Mr. W. E. de Winton. The manuscript was left in a forward, although incomplete, state at the death of the author, and to Mr. de Winton was assigned the task of revising, completing, and preparing it for press. How great and how difficult has been his share of the task, only those who have been to some extent behind the scenes are in a position to fully realise. Needless to say these difficulties have been overcome, and the work in its present form will long remain the standard authority on the subject. Thanks to the practice of issuing "preliminary notes," no new species, and only a single new race are named in the volume. Many revisions in nomenclature, for all of which Mr. de Winton seems to be responsible, are, however, made, and must apparently be adopted by future writers. The beauty and number of the coloured plates form a special feature of the work. The thanks of all naturalists are due to Mrs. Anderson for having arranged that the labours of her late husband should not be lost to the world.

Much interest attaches to the description, by Professor J. C. Ewart of Edinburgh, of a breed of pony from Iceland, the Faroes, and some of the Western Hebrides, characterised by the absence of callosities on the hind-legs and the sparse hairing of the base of the tail. The colour is yellow-dun, with black points, a dark stripe down the back, and traces of striping on the face and limbs. This breed, for which the name *Equus caballus celticus* (why "Celtic"?) is proposed, is regarded by its describer as the descendant of the horse domesticated by the inhabitants of Western Europe during the palæolithic age. Prof. Ewart also discusses the nature of the callosities, or warts, on the limbs of the horse-tribe, and comes to the conclusion that they are remnants of foot-pads, and have nothing to do with glands. He even goes so far as to correlate the fore-callosity with the supplemental pad on the fore-foot of a dog, while the hinder pair he identifies with the posterior pad on the foot of the Australian banded anteater (*Myrmecobius*).

We are glad to learn that Mr. de Winton has been appointed Acting Superintendent of the Zoological Society's Gardens, Regent's Park, in the room of Mr. C. Bartlett, retired. Mr. de Winton has already commenced operations on the unsightly bank by the canal where the Japanese and some other deer were formerly kept, and the work promises to be a great improvement. The deer have been removed to more suitable enclosures. Doubtless other alterations will be undertaken when time and other circumstances permit.

British Ornithological Notes.

Conducted by HARRY F. WITHERBY, F.Z.S., M.B.O.U.

THE MIGRATIONS OF THE FIELDFARE.—Attention has been drawn in the columns of KNOWLEDGE, from time to time, to Mr. W. Eagle Clarke's valuable work on the migrations of British birds. At the 1902 meeting of the British Association the Bird Migration Committee's report consisted of summaries by Mr. Clarke of the migratory movements of the Fieldfare and the Lapwing. In former summaries (viz., those of the migrations of the Song Thrush, White Wagtail, Syklark and Swallow) the lighthouse returns for the years of the special enquiry (1880-1887), supplemented by records published in various journals, formed the chief material upon which his conclusions were based, but last year Mr. Clarke made use of additional records obtained from the south coast light stations, while he himself spent a month at the Eddystone Lighthouse. The following is a brief abstract of Mr. Clarke's summary of the migrations of the Fieldfare as observed in the British Islands. I hope next month to give similar particulars of those of the Lapwing.

The FIELDFARES which visit the British Islands breed in Norway and Sweden, and there is no evidence to show that any individuals from the small colonies in various parts of Central Europe come to our shores. Compared to those of the Song Thrush the British migrations of this species are simple, and are typical of (1) a winter visitor to our islands from north-western Europe, and (2) of a bird of passage *en route* from and to its northern summer home and southern winter-quarters. There are in addition local winter movements due to climatic conditions.

Autumn immigrations.—The Fieldfare seldom quits its summer home until October. There are annual arrivals of comparatively small numbers in the prior half of October, but the first of the great autumnal immigrations is not to be expected until after the middle of the month. They continue to arrive until mid-November. The main immigration is on the east coast. In some seasons the birds arrive by a series of pronounced movements, while in others a single "rush" is recorded. These great immigrations often extend from the Shetlands to the Wash. When only a single "rush" has been recorded, it has been followed or preceded by (or both) a steady influx covering the ordinary period of the autumnal incoming. After their arrival on the coast the Fieldfares soon find their way to accustomed winter quarters, including those in the western districts. A migration of lesser extent passes down the west coast of Scotland, the Outer Hebridean branch of this stream reaching the north of Ireland. These western movements are not performed simultaneously with those on the east coast, and the birds probably reach and pass down our Atlantic seaboard by an overland route. The Fieldfares, however, which regularly travel south by way of the Outer Hebrides seem to reach that far western route by way of the Faroes—a remarkable fact because these birds are not found in Iceland.

Autumn Passage and Emigration.—An autumn passage to winter quarters beyond the British Isles is chiefly observed on our east coast, and immediately follows the immigrations of the latter half of October and the first half of November. A number of the immigrants observed on the west coast also proceed southwards.

Winter Movements and Emigration.—On the advent of snow and cold the Fieldfares quit the higher grounds and seek the lowlands, the coast and the south. In seasons of exceptional cold, vast numbers of Fieldfares, in company with other birds, pass southwards, as well as westwards, to Devon and Cornwall, and also many cross the Channel to south-western Europe. But, unlike some other birds, they do not cross St. George's Channel to Ireland from the south-east. These migrations depend entirely upon the weather. A small number of Fieldfares winter in Southern Scandinavia, and sometimes some of these are driven southwards and appear in Shetland and Orkney.

Spring Immigration from the South.—Towards the end of March, throughout April, and sometimes down to the early days of May, the Fieldfares which have wintered in or retreated to countries south of Great Britain return northwards.

Spring Passage and Emigration.—The departure northwards of the Fieldfares which have wintered with us and of those birds of passage just mentioned does not commence until early in April, and generally lasts until the first week in May, but is sometimes prolonged into the middle of

that month. The earliest appear to leave in small parties either alone or with other species, but those that follow late in April and in May leave the east coast in great flocks and in company with many other emigrants. There are also important emigrations on the west coast, and chiefly in Scotland, which receives the Irish birds *en route* for the north. This western passage proceeds throughout April and lasts until mid-May, but no great general flights are witnessed. There is also much overland emigration from western districts to the east coast performed throughout Great Britain.

Before proceeding to the coast for departure, Fieldfares assemble and form flocks in the various districts in which they have wintered, and are very noisy and restless for several days before they finally quit their winter haunts.

This species is extremely wary, and is less frequently killed or captured at the lanterns of the light stations than any of its congeners.

Breeding of the Red-necked Phalarope in Ireland.—An event of very great interest to students of British birds is recorded by Mr. Edward Williams in the *Irish Naturalist* for February, 1903 (pp. 41-45). Mr. Williams proves beyond doubt that the Red-necked Phalarope breeds and has bred for some years at all events in the west of Ireland. He thinks it best to keep the exact locality secret, which is a very wise precaution, since those who make the vain boast of having British-taken eggs are usually most unscrupulous as to how they obtain them. Except for one example shot in November, 1891, and a doubtfully authentic one in 1902, the Red-necked Phalarope was unknown even to visit Ireland until last July, when Mr. Williams received some specimens to stuff from a gentleman in the west of Ireland, who wrote "The birds breed here, and have, according to my keeper, done so for many years." In August the same correspondent sent a chick as incontrovertible proof of this fact, and wrote "During my tramp through the bog I counted seventeen (Red-necked Phalaropes), but there may have been many more; the most of the birds I saw were females. . . . I am surprised that these little chicks are able to survive their many enemies, especially as there are a lot of Black-backed and other Gulls on the bog." The Red-necked Phalarope breeds chiefly in the arctic regions, of both the Old and the New world, but it still nests also in the Shetlands, Orkneys, and Outer Hebrides, but in very greatly reduced numbers. The present discovery of its breeding in Ireland is a most interesting southward extension of its known breeding range. Many ornithologists recognise that there is still much to be discovered in Ireland, but comparatively few have worked there, and it is to be hoped that this startling discovery may be the cause of a closer observation of birds in Ireland.

Notices of Books.

"Jena Glass and its Scientific and Industrial Applications." By Dr. H. Hovestadt. Translated and Edited by Prof. J. D. Everett, F.R.S., and Alice Everett. Pp. 419. (Macmillan.) 15s. net.—This translation of Dr. Hovestadt's history of the Jena glass industry, and the properties of Jena glass, is of importance if only to show those unfamiliar with the German language what German patience and scientific system has accomplished in one direction. In 1876 Abbe directed attention to the demands of science for better optical glasses, and discussed the requirements which should be satisfied. Five years later, Schott, who was interested in glass making, commenced with him an investigation of the directions in which improvements could be made, and, as the result of their labours, the first trade catalogue of the Jena Glass Laboratory was issued in 1886. This, however, was only the beginning of the industry. Experiments were still carried on, and, in addition to the six usual elements of glass, twenty-eight new ones were introduced by degrees in order to discover their effects. It was soon seen that by the introduction of new elements variation of the hitherto fixed relation between refraction and dispersion could be obtained. Boric acid was found to lengthen the red end of the spectrum relatively to the blue, while fluorine, potassium, and sodium produced the opposite effect. So the work went on, covering all the stages of manufacture until each one was understood and could be controlled. The first price list from the Jena Glass Works contained forty-four optical glasses, of which nineteen were of essentially new composition. In 1888 a supplement was issued containing twenty-four additional glasses, of which thirteen were new, and in 1892 another supplement contained eight more glasses, six of them being new. From the scientific side alone the results of these investigations are of deep interest, and commercially they have been the means of developing a most successful industry. In the volume under notice the physical and chemical properties of the various types of Jena glass are discussed, and the scientific and industrial applications indicated. The translators have done their work admirably, so that the text reads easily and not at all like a translation from the German. Moreover, in several places the argument has been simplified, and brief explanations have been interpolated where considered necessary. The book can thus be commended to the notice of opticians and students of optics generally.

"A History of Hindu Chemistry." By Prof. Praphulla Chandra Rāy, D.Sc. Vol. I. Pp. lxxix. + 176 + 41. (Williams & Norgate.) 12s. 6d. net. Illustrated.—There is a large amount of very interesting matter in this book, which traces the history of Hindu chemistry from the earliest times to the middle of the sixteenth century A.D., with Sanskrit texts, variants, translation and illustrations. A few references to alchemy occur in the Atharva-veda, in which gold is regarded as the elixir of life, while lead is considered as the dispeller of sorcery. In the alchemy of the West, lead, as is well known, is associated not with beneficent, but with gloomy influences. Prof. Ray recognises four periods in the history of chemistry in India: they are (1) the Ayurvdic Period, from the pre-Buddistic Era to about 800 A.D.; (2) the Transitional Period, from about 800 A.D. to about 1100 A.D.; (3) the Tantric Period, from 1100 A.D. to about 1300 A.D.; (4) the Iatro-Chemical Period, from 1300 A.D. to about 1550 A.D. He shows that in ancient India the useful arts and sciences, as distinguished from mere handicrafts, were cultivated by the higher classes. The priests then followed various professions, but when the Brahmins reasserted their supremacy on the decline or the expulsion of Buddhism all this was changed. The caste system was established in a rigid form, and a priestly class was set up, which discouraged the experimental study of medicine and other sciences. The effect is graphically described by Professor Rāy. "The intellectual portion of the community being thus withdrawn from active participation in the arts, the *how* and *why* of phenomena—the co-ordination of cause and effect—were lost sight of, the spirit of inquiry gradually died out among a nation naturally prone to speculation and metaphysical subtleties, and India for once bade adieu to experimental and inductive sciences." It will be evident from this brief mention of a few points that Professor Rāy's book is an important contribution to scientific literature, and students of the history of science will be glad that such an instructive selection from the records of Hindu chemistry is now available

"Zittel's Text-Book of Palæontology." Translated by C. R. Eastman and others. Vol. II. (Macmillan. 1902.) Pp. viii. + 283. Illustrated. Price 10s. net.—More than two years have elapsed since the appearance of the first volume of this translation (dealing with the Invertebrata), but in spite of the fact that during that period many important discoveries and advances have been made in palæontology, the text of the present volume departs less widely from the original than was the case with its predecessor. And it cannot be denied that, in the main, this adherence to the original lines is an advantage, for it must be confessed that some of the amendments made in the first volume (notably in the case of the Mollusca) can hardly be regarded as improvements. Nevertheless, there are instances where a slavish adherence to the original plan is not to be commended; this being notably the case with regard to the classification of the fishes, where Dr. Smith Woodward (who is responsible for

this section of the translation) has, against his own convictions, retained the division of the "Teleostomi" into the discredited Ganoids and Teleosts.

The present volume includes all the vertebrates save mammals, which latter are to constitute the third and final volume. As already said, Dr. Smith Woodward, the greatest living authority on the subject, has undertaken the translation and revision of the chapters on fossil fishes. Dr. E. C. Case, of Wisconsin, has done the same for the amphibians, and has collaborated with other authorities in the reptilian section of the work. For the birds, Mr. F. A. Lucas, of the U.S. Museum, is responsible.

As a whole, we have nothing but commendation for this volume, which displays on every page full evidence of the care and attention bestowed on its preparation by the translators. Although the figures are much less numerous than in the large edition of Zittel, they are amply sufficient for the needs of the ordinary student; and the descriptions of the genera and larger groups are concise and not over-loaded with detail. So far as we can see, the work (save for certain details of classification, to one of which allusion has been made above) is thoroughly up to date, and therefore a safe guide to the student.

Space does not admit of any attempt at detailed criticism, but it may be mentioned that the translators follow the original in classing the leathery turtle in the same subordinal group as the ordinary turtles—a course in which we think they are fully justified by the facts. On the other hand, we cannot agree with Mr. Lucas that *Palapteryx* is the proper name for the elephant-footed moa; neither do we like the use of the name Theromorpha for the extinct anomodont reptiles. But these are details. As a whole, the book seems singularly free from misprints and other typographical errors, but we notice that in the figure of the quadrate of *Mosasaurus*, on p. 155, there is no indication in the legend as to the part of the skeleton to which the specimen belongs. The low price of this excellent volume renders it within the means of almost every student.

BOOKS RECEIVED.

Life and Letters of Thomas Henry Huxley. By his Son, Leonard Huxley. (Macmillan.) In three volumes. 12s. net.

Real Things in Nature. By Edward S. Holden, SC.D., LL.D. (Macmillan.) Illustrated. 3s. 6d.

In the Andamans and Nicobars. By C. Boden Kloss. (Murray.) Illustrated. 21s. net.

Nature Student's Note Book. By the Rev. Canon Steward, M.A., and Alice E. Mitchell. (Constable.) 2s. net.

Nature Studies (Plant Life). By G. F. Scott Elliot, M.A., B.SC., F.L.S., F.R.G.S. (Blackie.) Illustrated. 3s. 6d.

Teaching of Modern Languages in Schools and Colleges. By D. T. Holmes, B.A. (Paisley: Alexander Gardner.)

Bromide Printing. By Rev. F. C. Lambert, M.A. (Hazell, Watson & Viney.) Illustrated. 1s. net.

Enlargements: Their Production and Finish. By G. Rodwell Smith. (Hazell, Watson & Viney.) Illustrated. 1s. net.

Experiments on Animals. By Stephen Paget. (Murray.) 6s.

What Star is it? Tablets for identifying Unknown Stars. By Herbert W. Harvey. (Spottiswoode & Co., Ld.) 1s. net.

Theoretical Geometry for Beginners. By C. H. Allcock. (Macmillan.) 1s. 6d.

Practical Exercises in Light. By Reginald S. Clay, B.A., D.SC., (Macmillan.) 2s. 6d.

Geometry. By S. O. Andrew, M.A. (Murray.) 2s.

Design of Dynamos. By Silvanus P. Thompson, D.SC., F.R.S. (Spon.) Illustrated. 12s. net.

Practical Exercises in Geometry. By W. D. Eggar, M.A. (Macmillan.) 2s. 6d.

Spirals in Nature and Art. By Theodore Andrea Cook, M.A., F.S.A. (Murray.) Illustrated. 7s. 6d. net.

Religion for all Mankind. By Rev. Charles Voysey, B.A. (Longmans.) 2s. 6d. net.

The Old Testament: In the Light of the Historical Records of Assyria and Babylonia. By T. G. Pinches, LL.D., M.R.A.S. (S. P. C. K.) 7s. 6d.

Scene of our Lord's Life. By R. Waddy Moss, D.D. (Hodder & Stoughton.) 1s.

On the Avifauna of the Outer Hebrides, 1888-1902. By J. A. Harvie-Brown, F.R.S.E., F.Z.S. (Reprinted from the *Annals of Scottish Natural History.*) (Edinburgh: David Douglas.)

South-Eastern Naturalist for 1902. (Stock.) 2s. 6d. net.

British South Africa Co.—Report upon the Present Condition of Rhodesia. By J. F. Jones, C.M.G.

Fire Brigade Reform. By Capt. Shean. (Fisher Unwin.) 6d.

List of Second-Hand Instruments. C. Baker, 244, High Holborn, W.C.

Catalogue of Fine Art Photographs. Erdmann & Schanz, 116, Leighton Terrace, Bedford Hill, Balham, S.W.

FAMILIAR BRITISH WILD FLOWERS AND THEIR ALLIES.

By R. LLOYD PRAEGER, B.A.

II.—THE ROSE FAMILY.*

THE *Rosaceæ*, although their flowers are so different in appearance from those of the *Leguminosæ* (which were briefly dealt with in my last article), are nevertheless closely related to them, and may naturally be considered after them. The Rose family forms a tolerably large group of plants, differing widely in appearance, and while they are conveniently grouped together in one Natural Order, they nevertheless embrace several sections so well marked that these have often been treated as separate Orders. The *Rosaceæ* number over a thousand species—trees, shrubs, and herbs—which are distributed all over the world, but are, in the main, plants of the temperate regions of the Northern Hemisphere. The most striking feature of the Order is the fleshy fruits possessed by many of them, which, by cultivation, yield us the greater number of our native fruits. Equally famous is the wonderful range of beautiful blossoms that have been produced by cultivation of certain species of the typical genus of the Order, *Rosa*. Various parts of a large number of plants of the Order possess medicinal properties. The bark and root of many are astringent, owing to the presence of tannin. More well-known is the presence of prussic acid in the sub-orders *Drupaceæ* (Plums, &c.) and *Pomaceæ* (Apples and Pears). This violent poison has so powerful a taste and odour, that a minute quantity is immediately recognizable, as we may notice especially in the Bitter Almond. It is present in the seeds of most members of these sub-orders, and often also in the leaves, as in the common Cherry Laurel (*Prunus Lauro-cerasus*), which contains enough prussic acid to kill in a short time insects which are enclosed with a few crushed leaves.

Let us briefly review the various sub-orders into which *Rosaceæ* may be divided. *Chrysobalaneæ* are the only group which is not represented in the British Islands. These are tropical and sub-tropical trees and shrubs, found both in the Old and New World. Most of them have stone-fruits; to this section belongs the Cocoa Plum (*Chrysobalanus Icaco*) of the West Indies. *Pruneæ* is a group of much economic importance, including as it does many well-known stone-fruits, such as Almond, Peach, Nectarine, Plum, Damson, Apricot and Cherry. Here belong also the Cherry Laurel and Portuguese Laurel of our shrubberies. This is essentially a North-Temperate group of trees and shrubs. *Spiræaceæ* are also chiefly North-Temperate. The Meadow-Sweet (*Spiræa Ulmaria*), which will serve as a type, has a fruit very different from those of the last group, consisting of a little ring of twisted follicles. *Spiræa* is the

FIG. 1.—Fruit of the Meadow-Sweet (*Spiræa Ulmaria*). Half natural size.

* For the use of the figures illustrating this Article, the writer expresses his obligation to Messrs. C. Griffin & Co. They are taken from his "Open-Air Studies in Botany."

best known genus of the sub-order, and includes a number of shrubs and herbs that are grown in gardens for the sake of their graceful foliage and pretty clusters of white or red flowers. The *Dryadeæ* derive their name from the genus *Dryas*, of which one species belongs to our country—the beautiful little alpine plant *D. octopetala*, or Mountain Avens. Here also belongs the genus *Potentilla*, famed for the number of beautiful herbaceous species which it includes. The best known genera, however, are *Fragaria* and *Rubus*, the former of which yields the luscious Strawberry, the latter the Raspberry and Blackberry. In most of the other species the fruit is quite dry. *Poterieæ* forms a curious degraded group of *Rosaceæ*, with flowers strangely different from those, such as Dog Rose, Apple Blossom, Hawthorn, or Bramble, which we associate with the Order. The gay cup-shaped corolla which gives beauty and character to the flower of most of the *Rosaceæ*, is in many plants of this group entirely suppressed. The *Poterieæ* are like several of the preceding groups found chiefly in the North-Temperate zone, but its largest genus, *Cliffortia*, is characteristically South African. The sub-order *Roseæ* includes only the genus *Rosa*. The glorious array of cultivated Roses are the offspring of a few wild foreign species, notably *R. centifolia*, *R. gallica*, *R. alba*, *R. indica*, *R. bengalensis*; and the British *R. arvensis* (Trailing Dog Rose), and *R. rubiginosa* (Sweet Briar.) The Roses are essentially a North-Temperate group, a few extending southward into the tropics, but none reaching the South-Temperate regions. Lastly there is the sub-order *Pomaceæ*, so called from the characteristic fleshy fruit or *pome*, which is borne by its members, such as the Apple and Pear. Sometimes the fruit is stony, as in the Hawthorn, but more frequently coriaceous, as is found in the Quince, Pear and Apple.

Let us now consider the British species of *Rosaceæ*, and note their number, distribution, and the various points of interest connected with them. There is a difficulty in stating the total number of British species, owing to the varying value that has by different botanists been allowed to the puzzling series of Brambles, to which may be added the Roses. Thus while Hooker (*Student's Flora*) reduces the British species to 45, by lumping the fruticose Brambles under *Rubus fruticosus*, L., and treating certain other segrates similarly, the *London Catalogue* lists over 150 species, by allowing specific rank to a large number of Brambles and other segregates. The British *Rosaceæ* are, speaking very generally, herbs, shrubs, or small trees with a wide distribution, with graceful forms and pretty fragrant flowers, white and yellow being the prevailing tints. Of the sub-order *Pruneæ*, we have the genus *Prunus* alone, represented by several species. The tough black-stemmed Blackthorn or Sloe (*P. spinosa*) with its thorny branches and bitter fruit, is well known. The closely allied *P. insititia* (Bullace), and *P. domestica* (Wild Plum) are more plum-like small trees, and doubtfully indigenous. Then we have three species of Cherry. *P. Cerasus* (Dwarf Cherry) has bitter red fruit, and the larger *P. Avium* (the common Wild Cherry) has also bitter fruit, which is red or black. The latter is the origin of our many garden Cherries. The Bird Cherry (*P. Padus*) bears its pretty blossoms, not in umbel-like clusters like the last two, but in graceful racemes. The fruit is small, black, and bitter. Of the three Cherries, *P. Cerasus* alone has a restricted range in our islands, being distinctly southern.

The *Spiræaceæ* are, like the *Pruneæ*, represented in these countries by only one genus, *Spiræa*, which numbers but two native species. The delightful Meadow-Sweet (*S. Ulmaria*) needs no description. Its bold growth, its striking foliage, deep green above, white beneath, with deeply-cut pinnæ and curious little leaflets between, and its cloudy masses of creamy fragrant flowers, are one of the dearest features of our English meadows. The other native species, the Dropwort (*S. Filipendula*), is an equally pretty, though less striking plant, with beautifully cut pinnate leaves and white flowers. The roots bear peculiar conspicuous knobs. While in Great Britain it is widely spread, it has in Ireland a peculiar limited range, occurring in great abundance over a small portion of Clare and Galway, and there only.

Turning to the *Dryadeæ*, we find ourselves face to face with the bewildering Brambles. We can easily discriminate the Raspberry (*Rubus Idæus*) with its pinnate leaves and red fruit. Its stems are upright and covered with weak prickles, and it does not attempt to climb. Then we have two herbaceous species, also easily recognized—the Stone Bramble (*R. saxatilis*), with far-creeping slender barren stems and short upright flowering ones, which eventually bear red fruit; and the small Alpine Cloud-berry (*R. Chamæmorus*), with entire Lady's-mantle-like leaves and orange fruit. And then remains the Blackberry group. These are interesting to us as being good examples of "hook-climbers." Their stems are furnished with very strong hooked prickles—remarkable structures, arising, like hairs, from the skin, not from the wood, as do, for instance, the thorns of the Hawthorn. By aid of these prickles, the Brambles support themselves amid tangled thickets, and may be often seen bursting into blossom 10 or 15 feet up in the air. It is interesting to note that the long arching stems in autumn, when their growth is nearly over, frequently again seek the ground,

FIG. 2.—Rooted tip of Bramble-shoot.

and their tips root themselves firmly in the soil. Next year the shoot produces flower and fruit, and dies. But from the rooted tip proceeds a fresh plant, which in turn loops away and produces new offspring far from the parent. The plant may in this manner travel forward at the rate of 20 feet or more per year, and may cross obstacles such as a ten-foot wall in a single season.* These Brambles were grouped by Linnæus under one species (*Rubus fruticosus*). But when we look into them, great differences are noticeable as regards growth, habit, colour, texture, shape, and size of leaf and flower; and in the form, number, and arrangement of prickles. Hence numerous other names have been bestowed on apparently distinct forms, and the process has gone on until the latest work on the British Brambles lists one hundred "species" under Linnæus' *R. fruticosus*, with numerous sub-species and varieties. It is difficult to explain such a complicated tangle of closely allied forms. The most nearly related genera, such as *Potentilla*, display no

* See *Irish Naturalist*, March, 1897, and February, 1902.

such puzzling series among their species. Apparently, in *Rubus* the innate power of variation is being exercised to a high degree, and could we look forward, we might expect to find that by a further divergence along the present lines of variation, and a suppression of the intermediates, a group of well-marked species might ultimately arise from *Rubus fruticosus*.

Closely allied to *Rubus* is *Fragaria*, the Strawberry, as valuable to us as the Raspberry on account of its delicious fruit. The difference in the appearance of the fruit of these two genera is due to the fact that whereas in the Raspberry the edible fruit is formed by a number of soft juicy carpels set on a comparatively hard receptacle, in the Strawberry the carpels are dry, and the receptacle on which they are set swells up and becomes sweet, juicy, and coloured. The little Wood Strawberry (*F. vesca*) is our only native species. The luscious fruit of our gardens is due to the cultivation of the Hautbois Strawberry (*F. elatior*), a plant chiefly of eastern Europe. The well-known and pretty Potentillas come next in order. Including *Sibbaldia*, *Tormentilla*, and *Comarum*, which are sometimes reckoned distinct genera, the British species number twelve, all but one perennial herbs. Many of these are familar wild-flowers—the favourite Silverweed (*P. Anserina*), the Creeping Cinquefoil (*P. reptans*), the Tormentil (*P. Tormentilla*), all with yellow flowers, and the Strawberry-like *P. Fragariastrum*, which has white blossoms. The Marsh Cinquefoil (*P. palustris*) is easily recognised by its upright stems, pinnate leaves, and dull red-brown flowers. Among the rarer species are the Shrubby Cinquefoil (*P. fruticosa*), a small bushy gregarious shrub, looking in the distance like low Gorse. It is a very local plant, occurring in the North of England and the West of Ireland. *P. Sibbaldi* is a little Scotch alpine, with minute yellow flowers. *P. alpestris* is also alpine, with more conspicuous yellow blossoms. The rarest British species is *P. rupestris*, a comparatively tall plant with pinnate leaves and white flowers, found on limestone rocks in Montgomeryshire. *Dryas* has but one British species, the delightful *D. octopetala*, a far-creeping prostrate shrub covering mountain rocks with a sheet of dark-green shining leaves, white underneath, from among which rise singly the large white blossoms, which give way to clusters of feathery fruits, each achene being furnished with a long awn—the only instance among British *Rosaceæ* of a fruit adapted for wind-dispersal. Of *Geum*, or Avens, we have two species. *G. urbanum* is a common wayside plant, growing a couple of feet in height. Its fruits are furnished with long hooked points (the persistent styles) which easily attach themselves to the wool of passing animals, and thus secure for the seeds a wide dispersal. *G. rivale*, the Water Avens, is generally like the last, but has larger drooping reddish flowers, which do not open widely.

Turning now to the *Poterieæ*. Three British genera belong here :—*Poterium*, *Alchemilla*, and *Agrimonia*. The two species of *Poterium*, *P. officinale* (Greater Burnet) and *P. Sanguisorba* (Lesser Burnet) are well-known English wild-flowers. Both have pretty pinnate leaves, from among which rise slender stems bearing dense egg-shaped heads of small flowers, which are dark purple in the former, greenish or purplish in the latter. If the flowers be examined, they will be found to be destitute of corolla. Four coloured pointed calyx-segments take the place of petals. In *P. Sanguisorba*, moreover, the flowers are made male or female by the suppression of one or other set of essential organs. Both plants are wind-fertilised, and have the elevated dense inflorescence, inconspicuous blossoms, and conspicuous stamens and pistils, characteristic of such plants. *Alchemilla* supplies us with several pretty herbs. The common Lady's-mantle (*A. vulgaris*), with fan-like leaves and golden-green flowers is well known; and the little *A. alpina*, frequent on our higher mountains, is justly a favourite in gardens. It is the beautiful silkiness of the under-side of the leaves that forms its most pleasing character. *A. arvensis* (Parsley Piert), is a quaint little annual, common in cultivated ground, with inconspicuous green flowers. In *Alchemilla*, as in *Poterium*, the corolla is absent, but the eight-parted calyx, of which each alternate segment is smaller than its neighbour, gives the appearance of a four-parted calyx, and a four-parted green corolla. In *Agrimonia*, alone of our *Poterieæ*, a corolla is present. The flowers of the Agrimony, borne in long spikes, have yellow petals. The fruit of Agrimony is interesting, being furnished round the top with a ring of hooked bristles, which like the hooked styles of *Geum*, assist seed-dispersal by becoming entangled in the hair of passing animals—or in one's stockings. *Agrimonia Eupatoria*, the common Agrimony, is a well-known roadside wild-flower. *A. odorata* is very similar, but larger and with more spreading fruit-bristles.

Fig. 3.—Alpine Lady's-mantle (*Alchemilla alpina*). Half natural size.

The *Roseæ*, which consist of the genus *Rosa*, are distinguished by their fruit, in which the numerous dry nuts are enclosed by the calyx-tube, which becomes fleshy and coloured, giving the appearance, in botanical parlance, of an *inferior* fruit. The Roses are prickly shrubs, usually climbing by means of their hooked prickles. The species are found chiefly in North-Temperate regions. The genus resembles *Rubus* in possessing many forms which approach too close to each other to be satisfactorily treated as species. The number of Roses in our country may be variously estimated at 7 to 13, according to the amount of "splitting" which we are prepared to indulge in. All have large and showy flowers, and are among the most delightful features of our English hedge-rows. To attempt to discriminate the various species in an article of this kind would be futile. The most easily distinguished are the little Burnet Rose (*R. spinosissima*), perhaps the most deliciously fragrant of our species, and the Trailing Rose (*R. arvensis*), whose large white blossoms are almost scentless.

To come finally to the *Pomaceæ*. Here belong the genera *Pyrus* (Apple and Pear), *Cratægus* (Hawthorn), and *Cotoneaster*. Of *Pyrus*, the best known species is *P. Malus*, the Crab-Apple, from which the many kinds of cultivated apple are derived. The variety *acerba*, which is truly native with us, is a more picturesque shrub, both as regards flower and foliage, than var. *mitis*, which, though equally common, is believed to have always a garden origin. The Wild Pear (*P. communis*) is, like the last, doubtfully native, though found often in wild ground. Of several other species of *Pyrus*, the most familiar is the Mountain Ash (*P. Aucuparia*), which alone of British species possesses pinnate leaves. The White Beam (*P. Aria*), with egg shaped serrate leaves, white and felty on the under-side, is also a familiar tree. Turning to the

genus *Cratægus*, our only species, the Hawthorn, needs no description. In this genus the seeds are enclosed in a bony case, instead of in cartilaginous cells as in *Pyrus*. The remarkable thorns which render the plant so formidable are the attenuated terminations of the branches. They resemble in this respect the prickles of the Gorse, and have a quite different origin from the prickles of the Bramble or Rose. The function of the Hawthorn spines is undoubtedly protective. The last genus of *Pomaceæ*, *Cotoneaster*, has, like *Cratægus*, but a single British species, and this is confined to a single locality—*C. vulgaris*, which grows, though now nearly extinct owing to the incursions of thoughtless collectors, on Great Orme's Head. It is a small shrub, with ovate leaves, pink flowers, and red berry-like fruit.

MICROSCOPY

Conducted by M. I. Cross.

NOTES ON THE COLLECTION, EXAMINATION AND MOUNTING OF MOSSES AND LIVERWORTS.

By T. H. Russell.

(Continued from page 45.)

Before dealing in detail with the subject of mounting, let me add a few words with reference to registering slides and specimens, &c. My plan has been to have one general register of slides, in which the various mounts are entered consecutively as completed. Each page is ruled in five columns, headed respectively, "Number," "Date when gathered," "Name," "Habitat, &c.," and "Remarks." The label on the slide, in addition to briefly recording the name, locality, and date, bears the number corresponding with the entry in the Register, and this number is also marked on the packet containing some spare material for future use, if required. I also have a copy of the "London Catalogue of British Mosses and Hepaticæ" (a work, by the way, of which we are badly in want of a new edition, that of 1881 having been long since exhausted), which has been inter-leaved, the numbers in the "Catalogue" corresponding with the names of the various plants being repeated on the added pages. Opposite to each of these numbers I write the numbers of the slides in my collection referring to the particular plant in question. Thus, *Bryum alpinum* is numbered 337 in the "Catalogue," and against this number I find entered "105, 719," which gives me the references to the two slides of this species in my collection. By the help of these two registers I can always find the slides I possess of any particular moss, and also the details of place and time where and when it was found. I have another register, which is divided into columns (two to a page), each of which is numbered and named in correspondence with the "London Catalogue," and there I can enter a short note of any moss I may meet with but which I do not wish to mount. Lastly, I have a small book in which I record the medium used for mounting and sealing each slide, with the date of each of these operations. I have found the above registers extremely useful, and if entered up systematically they really give very little trouble.

II.—Mounting.

Owing to their small size and the facility with which their original freshness can be revived, as already noticed, mosses can be far more satisfactorily preserved than is possible with ordinary flowering plants. The greater number may be readily mounted on the ordinary glass slips, and in this form they not only occupy a comparatively small storage space, but remain, for all practical purposes, as fresh as when they were gathered. I have specimens in my collection now that were put up twenty years and more ago, and which have altered little in appearance in the meantime.

I have tried several materials and compounds for mounting purposes, but unhesitatingly give the palm to glycerine jelly, both on account of the facility with which it may be manipulated, and by reason of its admirable preservative powers. I have for many years made my own jelly according to the following receipt, which is a slight variation on that given in Carpenter's work on "The Microscope." Take 2 ounces (by weight) of "invalid" gelatine, 6 ounces of water and 6 of glycerine. Soak the gelatine in the water until it swells (this takes about 40 minutes), then place the vessel containing the gelatine and water (a jam-pot is very serviceable; it should be provided with a cover of some kind) in a saucepan of water, and boil over a slow fire until the gelatine melts. When the gelatine is cool, but still liquid, add the white of one egg, and mix well. Boil the gelatine, as before, until it becomes thick with the coagulated albumen—this takes about half an hour; add the glycerine and 25 or 30 drops of carbolic acid and mix well; strain through filter-paper before the fire, and a clear pale yellow jelly should be the result.

I propose to describe my ordinary process of mounting with this medium. The specimen to be mounted must first be cleansed from all earth and grit in water, and the spores and air gently expelled from any capsules by means of the dissecting needles; it must then be left to soak for at least 24 hours in a mixture composed of water 1½ ounces, rectified spirit 1½ ounces, and glycerine 5 drachms; the small china pans in which moist water colours are sold are very useful for this purpose. When the specimen is taken from this preparatory liquid in readiness for mounting care must be taken to remove the fluid adhering to it as far as possible; this may be done by placing it on a glass slip, and tilting this so as to allow the superfluous liquid to drain off, and then, last thing, applying blotting-paper.

A hot-water bath is essential for mounting with glycerine jelly; mine consists of a small glass tumbler, provided with a closely-fitting tin cap or lid. A piece is cut out of this lid at the margin, leaving a space just wide and large enough to admit the neck of a small glass bottle containing the jelly; this bottle can thus hang in the hot water in the tumbler, when the lid is in place, by means of its lip, which rests on the top of the tin cover, and in this way the jelly is kept melted, and is, moreover, close at hand for use. When my mounting is likely to take long I wrap a piece of flannel round the tumbler in order to retain the heat in the water as long as possible. The glass slip on which the mount is to be made, as also the cover-glass, must be first carefully cleaned in water; acetic acid is useful for removing all traces of grease, and nothing serves better for drying the glasses than an old, soft cambric handkerchief. The glass slip is placed upon the flat tin cover of the hot-water bath, and the specimen, after being freed from the preparatory fluid, is laid on it. A few drops of the liquid jelly are then taken from the bottle by means of a small glass pipette, and are dropped on to the specimen. While the jelly is kept liquid by the heat of the water-bath all air-bubbles must be carefully removed with the dissecting needle, and here the binocular dissecting microscope will be found most helpful. Too much care cannot be taken in this somewhat tedious process, as the success of the slide practically depends upon the thoroughness with which it is carried out.

Nothing detracts more from the appearance of a mount when viewed under the microscope than the presence of these disfiguring silvery globes, lurking among the delicate leaves, or perhaps entangled in the teeth of the peristome, and my own rule always is that, rather than allow a serious blemish of this kind, the slide must be sacrificed, or the mount be recommenced. I have found it a great help in many cases, especially when an object likely to retain air, or an undue amount of the preparatory fluid is in hand—as, for instance, a large empty capsule, or a plant with the leaves closely covering the stem—to put it into a little jelly on a spare glass slip, and then to extract the air as far as possible before transferring it to the slip on which it is to be mounted. The whole plant thus becomes more or less saturated with the melted jelly, and the air-bubbles cannot find their way back to the mount, as they are apt to do if the whole process is carried out on the one slide. A second hot-water bath is not unfrequently of much assistance.

When everything has been prepared, and the specimen is in place, immersed in plenty of the liquid jelly, the cover-glass is taken up with the forceps, and gently lowered on to the jelly, beginning from the left-hand side, driving the jelly (and too often, alas, the specimen also) before it as it is allowed gradually to fall into place. This is an operation of no little delicacy, as if great care is not taken a large bubble of air will make its way in at the last moment. If, as frequently happens, the putting on of the cover-glass has caused a displacement of the object, this must be rectified before the jelly is allowed to set, and here the bent dissecting-needles will be of great service, as a considerable amount of re-arrangement can be effected with one of them, and stray air-bubbles may also be removed without disturbing the cover-glass. The slide is now taken from the bath and allowed to cool, and in a few minutes the jelly will have so far solidified that the mount can be examined under the microscope, when, should any serious defect be disclosed, the jelly must be re-melted, and the shortcoming be rectified. The final process consists in removing the superfluous jelly from around the cover-glass with a knife, cleaning the slide from all trace of the jelly, a handkerchief moistened at the lips is the most efficient method, and sealing the cover-glass round the margin with some kind of varnish. I have tried a good many sealing materials, and, on the whole, much prefer copal varnish, as sold by artists' colourmen, thinned with a little benzine. One special advantage arising from its use is that if any portion of the object happens to be fixed near to the edge of the cover-glass, it can nevertheless be seen through the practically colourless varnish. I may add that I usually mount two cells on each slide ; in the larger of them I place a small portion of the moss, together with a few capsules, if possible in various stages of growth, and two or three perichætial leaves, while the other cell contains some leaves dissected from the plant (where of importance from both stem and branch), and a few pieces cut from the mouth of the capsule to show the peristome.

(To be continued.)

MONOCHROMATIC LIGHT.—The use of light filters or screens has of late become increasingly appreciated, and numerous attempts have been made to secure a light filter of definite value, which shall pass a maximum quantity of light. A fresh interest has been added to the subject by the method of obtaining monochromatic light which was exhibited by Dr. E. J. Spitta at a recent meeting of the Royal Microscopical Society.

It has to be remembered that strictly monochromatic light —that is, a selected ray of the spectrum of one uniform wave length—cannot be secured by light filters only. All the manufactured screens are only approximately monochromatic—that is, by the judicious selection of ingredients they absorb certain undesirable colours.

Practical monochromatism can, however, be secured with a suitable arrangement of prisms, and this, undoubtedly, is the most precise method of working. It is not possible, however, with the majority of workers for prisms to be brought into regular use, and a recapitulation of the best screens that are known will be of interest.

In passing, the advantages of light screens or filters may be indicated. In the first place the possibility of a lens to divide fine detail is in a measure increased. Mr. Nelson has stated that monochromatic blue light increases the effective working of objectives of low aperture 14 per cent., but beyond ·90 N.A. the value in this connection is not worth consideration, but it is of special value in producing a clearer image of the specimen under examination.

In effect, if a light of shorter wave length than that possessed by white light be used for illuminating purposes, whether obtained by prisms or screens, the effective aperture of a lens is increased. A reference to a numerical aperture table will show this at once, the lines per inch resolvable by blue light being considerably in excess of those resolvable by white light with identically the same lens.

(To be continued.)

DISSECTING NEEDLES.—A dissecting needle of suitable shape is often of great convenience. The following brief note may be of interest. If it is desired to bend it, it should be heated to a dull red and allowed to cool gradually, it can then be bent into any shape, and if desired an edge can be ground or filed. To re-harden, heat as before to blood-red heat, and plunge into cold water. In this condition it will be found too hard and liable to easily break. It should be rubbed bright on fine emery paper, then held in a spirit lamp until it assumes a pale straw colour, and again dipped into cold water. The correct temper for use will then be obtained.

PRACTICAL SCHEME.—A correspondent has sent from Oporto for distribution a quantity of the protecting case of the flower cone of *Pinus pinaster*. The scales can be either mounted in balsam, or viewed as opaque objects. I shall be pleased to send a small quantity to applicants sending a stamped addressed envelope, accompanied by the coupon to be found in the advertisement pages of this issue.

NOTES AND QUERIES.

G. Damant (China).—On examining the specimens in the tube which you have sent, I found that two parasites were adherent to the abdomen of the cockroach. These are larvæ of the genus Rhipidophoridæ, and the winged specimen is the perfect insect. These parasites are nearly allied to the British *Metoecus paradoxus*, which is a parasite of the wasp. You cannot do better than proceed with the mounting of your insect parts in the manner described by Mr. Cole in *Modern Microscopy*. In order to overcome your difficulty with the insect mouth organs, etc., you will proceed as far as the clove oil stage, then take a slide and place the parts upon it in the desired position in a very little clove oil ; generally there will be enough oil about each part without adding any more. Now place a cover-glass over all, being careful that the specimens do not move, then apply some thin Canada balsam solution to the edge of the cover and let it run under so that it goes all round the specimens. There will probably be some air-bubbles, but they should be disregarded, they will disappear as the balsam dries. Put the slide aside for, say, fifteen minutes, then add more balsam, and so on until the space between the cover and slip remains entirely filled up with balsam. It should then be allowed to dry for a few days, wash off any excess of balsam with benzole, apply a coat of black varnish, let this dry, clean the slide with turpentine, and add another coat of varnish.

G. V-G.—All the objectives you name are high-class, but I am inclined to recommend for your special purpose the one made by Leitz. The lenses of smaller aperture for work on Diatoms would certainly not be so advantageous.

W. D. D.—The parasite of the *Hydra fusca* is *Trichodina pediculus*.

T. P. Thomson.—I am much obliged for your proposal, but am afraid that Diatoms of your locality would not be of general interest unless indeed you had discovered some new or very rare species.

G. F. Brown.—If you will kindly send me another sample of the Polyzoa, I will endeavour to identify it for you.

W. F. Albrow.—I have communicated with the consultant who interests himself in the particular department to which your query refers, and he suggests that the peculiar substance which you have found in your flagon of distilled water may be due, as you suggest, to a dirty vessel, in which case the growth would perhaps be a fungoid or gelatinous bacterial one, detached from the bottom of the vessel by the act of emptying it. He further suggests that it might perchance be due to the solvent action of the water detaching portions of the surface of the glass. This is common with alkaline solutions, especially ammonia, though the large size and circular shape of the described growth are difficult to reconcile with this idea. If any of the substance is still obtainable, the consultant would be particularly interested in examining it.

Communications and enquiries on Microscopical matters are cordially invited, and should be addressed to M. I. CROSS, KNOWLEDGE *Office*, 326, *High Holborn, W.C.*

NOTES ON COMETS AND METEORS.

By W. F. DENNING, F.R.A.S.

GIACOBINI'S COMET (1902 D).—This object continues well visible in pretty good telescopes, though it is decidedly small and inconspicuous. In March and April the comet will travel slowly to the

north-east amongst the stars in the northern region of Gemini. An ephemeris was given in Knowledge for February, 1903, and the following diagram will indicate the apparent path of the object until May. The motion of the comet will carry it near several fairly bright stars which will greatly facilitate its identification:—

March 7 ... Comet $\frac{1}{2}°$ South of ϵ Geminorum (Mag. 3·2).
April 8 ... Comet $\frac{2}{3}°$ North of τ Geminorum (Mag. 4·6).
,, 26 ... Comet $1\frac{1}{2}°$ North of α Geminorum (Mag. 2·0).

Path of Giacobini's Comet (1902 d). 1903, February 11—May 2.

The remarkable feature in connection with this comet is its great perihelion distance, which amounts to 2·75, or 256 millions of miles, and exceeds that of any other comet observed since 1729. The bright comet of that year had a perihelion distance of 4·0435, which is equivalent to 380 millions of miles! Barnard's comet of 1885 (IV.) was also somewhat exceptional in regard to the wide interval (2·295, or 213 millions of miles) separating it from the sun, but our present visitor is much more remarkable in this respect.

Giacobini's Comet (1903 a).—A comet was found at Nice on January 15, near β Piscium, and the position fell so near the ephemeris place computed for Tempel-Swift's comet that at first some uncertainty was felt whether it was a new object or a return of the periodical comet referred to. But the motion was soon found incompatible with that of the latter; the object proved a new comet approaching its perihelion and rapidly becoming brighter. Its motion was carrying it to the N.E., and at the opening of March the comet may be found close to γ Pegasi (*Algenib*), and will be nearly twelve times as bright as on the date of its discovery, when it was estimated of the 10th magnitude.

The Quadrantids.—The January Quadrantids, or Boötids, as they might more fittingly be designated, seeing that the small asterism formed by Bode (1801) between Boötes, Draco and Hercules, and called Quadrans Muralis, does not seem likely to be acknowledged either by present or future astronomers. There is always, however, a serious objection to changing a name which has become familiar by long usage, for doubts and complications naturally ensue, and it is questionable whether it is not desirable to retain an old title, inappropriate though it may appear, preferably to an alteration which must induce confusion.

The January meteor shower was fairly well observed this year, though the weather was very unsettled. On January 2 the display was extremely feeble; the maximum occurred on January 3, but it by no means formed a bright and abundant return. The mean position of the radiant derived from a number of independent determinations was at 228°+52°. In the *General Catalogue of Radiants* (1899) the average centre from 32 positions is at 230° 6+51°·1. Three pretty bright Quadrantids were doubly observed, and their real paths worked out as follows:—

1903.	G.M.T. h. m.	Height at beginning.	Height at ending.	Length of Path	Velocity per sec.	Radiant. ° °	Position over.
Jan. 3.	7 25	60	47	52	16	228 + 52	Wilts.—Hants.
,,	12 5	65	49	41	26	228 + 53	Herts.—Bucks.
,,	12 $59\frac{1}{2}$	67	54	30	20	227 + 50	Berks.—Hants.

A considerable number of pretty bright meteors (chiefly Quadrantids) were recorded, but the above appear to be the only accordances, for the observers were rarely watching the sky simultaneously.

Fireballs.—Several fireballs and bright long-pathed meteors were observed in January. Three of these made their apparitions during the severe frost and clear moonlit nights which prevailed during the second week of the month. Appearing as they did near the period of the full moon these objects managed to elude regular meteoric observers, but a considerable number of descriptions have been received from other sources. Fine meteors were also seen on January 25 and 28, and the following is a summary:—

January 10, 9h. 30m.—Brilliant fireball, about one-third as bright as the moon, directed very slowly from a radiant in Monoceros. Height 63 to 31 miles, and velocity 18 miles per second. An observer in N. Kent describes it as "a large comet with a tail of golden sparks only a few yards away, and coming within half a yard of the ground, then slowly ascending, wriggling like a serpent, until it mixed with the stars." 11 observations.

January 13, 6h. 15m.—Bright, long pathed, rocket-like meteor ascended from N. horizon and passed to S. over western counties of England. Height about 55 miles, and luminous flight of about 200 miles traversed at about 34 miles per second. Radiant near γ Boötis. 3 observations.

January 14, 7h. 7m.—Fireball about 2 × ♀, with slow horizontal flight over Rutland, Leicester and Stafford at an elevation of about 57 to 54 miles. Velocity 21 miles per second. One observer at Highgate, N., guesses the time of apparition as 5 or 6 minutes after 7, and says "the air was too cold for me to take my watch out." Radiant in Monoceros near E. horizon at 120° − 3°. 8 observations.

January 25, 7h. 59m.—Fine meteor of Jovian lustre travelled from S.E. to N.W. from over Surrey to Warwick, descending from a height of 95 to 16 miles. Radiant near ζ Geminorum. 4 observations.

January 28, 11h. 44m.—Fireball equal to Venus, with a long flight and slow apparent speed. Fell from a height of 62 miles above a point W. of York to 41 miles above a point closely E. of Bristol. Path 181 miles, and velocity about 20 miles per second. Radiant at 280° + 43° near α Lyræ, close to the N. by E. horizon. This meteor was well observed by Prof. A. S. Herschel, Slough, Mr. T. W. Backhouse, Sunderland, Mr. J. H. Bridger, Farnborough, Dr. H. Whichello, Chester, and others. 12 observations.

THE FACE OF THE SKY FOR MARCH.

By W. Shackleton, F.R.A.S.

The Sun.—On the 1st the sun rises at 6.50 and sets at 5.36; on the 31st he rises at 5.43 and sets at 6.28, thus during the month the day lengthens by 2 hours.

Spring commences at 7 p.m. on the 21st, when the sun enters the sign of Aries.

Sun-spots are of more frequent occurrence, and the sun's disc may be examined for small spots with some hope of reward.

The Zodiacal Light is now in the most favourable position for observation in the west for two or three hours after sunset.

There is an annular eclipse of the sun on the 29th, invisible in this country but visible over Eastern Asia.

The Moon:—

	Phases.	h. m.
Mar. 6	☽ First Quarter	7 14 p.m.
,, 13	○ Full Moon	0 13 p.m.
,, 21	☾ Last Quarter	2 8 a.m.
,, 29	● New Moon	1 26 a.m.

The moon is in perigee on the 10th, and in apogee on the 22nd.

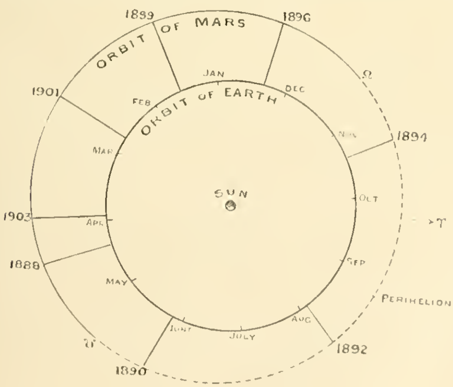
OCCULTATIONS.—The following are among the principal occultations visible at Greenwich:—

Date.	Star Name.	Magnitude.	Disappearance. Mean Time.	Disappearance. Angle from N. Point.	Disappearance. Angle from Vertex.	Reappearance. Mean Time.	Reappearance. Angle from N. Point.	Reappearance. Angle from Vertex.	Moon's Age.
			h. m.	°	°	h. m.	°	°	d. h.
Mar. 9	51 Geminorum	5·4	0 23 A.M.	153	113	1 1 A.M.	231	190	9 14
,, 10	α Cancri	4·3	4 59 P.M.	68	108	5 50 P.M.	316	353	11 7
,, 14	B.A.C. 4294.	6·1	9 29 P.M.	141	171	10 26 P.M.	264	292	15 11
,, 18	ζ^3 Libræ	5·8	1 6 A.M.	120	144	2 21 A.M.	274	288	18 15
,, 18	ζ^4 Libræ	5·4	2 41 A.M.	141	152	3 47 A.M.	250	251	18 16
,, 19	χ Ophiuchi	5·0	4 1 A.M.	94	100	5 25 A.M.	284	276	19 18

THE PLANETS.—Mercury is visible for the first few days of the month as a morning star in Capricornus. He is not favourably placed, and rises at the beginning of the month only about one hour in advance of the sun.

Venus now shines brilliantly in the western sky, and since the planet can be seen before it is dark she is available for observation for a considerable time. On the 1st she sets about 7.40 P.M., or 2 hours after the sun, and on the 31st at 9.15 P.M., or $2\frac{3}{4}$ hours after sunset. The apparent diameter of the disc is increasing; at the middle of the month it is 11″·4, whilst 0·9 of the disc is illuminated.

Mars is now at its best for easy observation, as the planet is in opposition to the sun on the 29th. The present opposition is more favourable than that of 1901, in that we approach nearer to the planet by some $3\frac{1}{2}$ millions of miles, the apparent diameter of the planet being 14″·57 as compared with 14″·17 at the last opposition. As will be seen from the appended diagram, the present opposition is not one of the most favourable, since the distance of the planet from the earth is 59 millions of miles, whilst under the best conditions the distance is only 35 million miles.



Opposition of Mars, 1903.

The latitude of the planet's centre is + 22°, thus the north polar cap is presented to us, and it is winter in the Martian southern hemisphere. On the 1st the planet rises at 8.30 P.M., and on the 31st at 5.45 P.M. The planet is describing a retrograde or westerly path in Virgo, and on the 22nd of the month will again pass close to γ Virginis.

Jupiter and Saturn are unobservable, being too near the sun.

Uranus is a morning star in Ophiuchus, rising about 3 A.M. near the beginning of the month. The planet is in quadrature with the sun on the 17th.

Neptune is on the meridian about sunset near the middle of the month; he is in quadrature with the sun on the 22nd. The planet is pratically stationary throughout the month, and is situated 5 minutes west of η Geminorum and 10′ south.

THE STARS.—About the middle of the month at 9 P.M. the positions of the principal constellations are as follow:—

ZENITH . No bright constellations in the zenith.

SOUTH . Cancer and Hydra on the meridian; Gemini high up, *Procyon* and *Sirius*, all a little to the west. Orion is to the south-west, and Leo (*Regulus*) to the south-east high up.

WEST . Taurus, Aries nearly setting, Auriga (*Capella*) high up. To the north-west Perseus, also Andromeda low down.

EAST . Virgo (*Spica* rising), Bootes (*Arcturus*). To the north-east Ursa Major high up, Corona, Hercules and *Vega* low down.

NORTH . *Polaris*; to the right, Ursa Minor, Draco; below, Cygnus, Cepheus; to the left, Cassiopeia.

Minima of Algol occur on March 12th at 2.51 A.M., on March 14th at 11.40 P.M., and March 17th at 8.29 P.M.

Chess Column.

By C. D. LOCOCK, B.A.

Communications for this column should be addressed to C. D. LOCOCK, Netherfield, Camberley, and be posted by the 10th of each month.

Solutions of February Problems.

No. 1.

(C. C. W. Sumner.)

Four Solutions (R to QB3, R × B, Kt to B3ch, Kt to B6ch). I must apologise for inadvertently printing this "revised" version of a position which appeared last year, particularly as the results of the revision have been so unsatisfactory.

No. 2.

(A. Lillie.)

Key move.—1. B to Ktsq.

If 1. . . . K × Kt, 2. K to B2, etc.
1. . . . K × P, 2. Kt to B6 or 2ch, etc.

Two or three solvers have found themselves in the same predicament with regard to this problem as the composer.

SOLUTIONS received from "Alpha," 2, 4; W. Nash, 3, 4; G. A. Forde (Capt.), 2, 4; "W. Jay," 3, 4; "Endirby," 3, 4; "Looker-on," 3, 4; A. H. H. (Croydon), 3, 0; W. H. S. M., 3, 4; G. W. Middleton, 3, 0; J. W. Dawson, 3, 0; "Quidam," 3, 4; J. W. Dixon, 3, 4; C. Johnston, 3, 4; H. S. Brandreth, 2, 4; H. F. Culmer, 2, 4.

J. W. Dixon.—Yes, postcards are more convenient.

W. Nash.—You are quite right in assuming that three points is the maximum for a two-mover, and six points for a three-mover. I quite agree with your estimate of *Fort Nachanand*, if only it had been sound.

"*Endirby.*"—Only two keys to a problem can score points. Duals no longer count this year.

L. C. T. (India).—The solutions for which you ask are as follow: W. H. Gundry (July, 1900), Kt to Q4; A. F. Mackenzie (August, 1900), B to R5 (or B to QB7); this is a two-move problem, erroneously printed as a three-mover. B. G. Laws (June, 1900), incorrectly diagrammed, and reprinted in the following number. The White Knight at QRsq should be a King. Solution Kt to B6.

J. C. Candy.—Thanks for the problems. You will see that I have at last found room for your former batch.

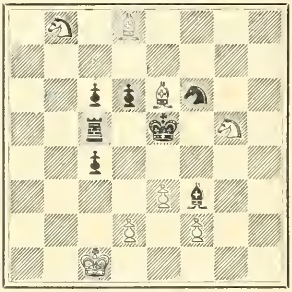
W. Jay and G. Woodcock.—Any criticisms of the problems at present would, I think, be premature.

PROBLEMS.

By J. C. Candy.

No. 1

BLACK (7).

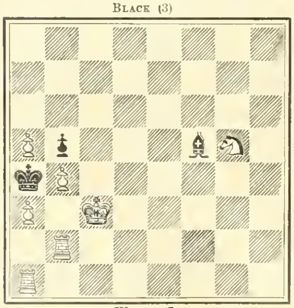


WHITE (8).

White mates in two moves.

No. 2.

BLACK (3)



WHITE (7)

White mates in three moves.

[As our stock of problems is now nearly exhausted, we hope that those readers of this page who are composers will send some of their compositions in either two or three moves.]

PROBLEM TOURNEY.

Through the courtesy of the six solvers who are acting as preliminary judges in the tournament, I am able to publish their award this month, and shall hope to give my final award in the April number. The following problems have received votes:—

PROBLEM.	J. D.	W. J.	C. J.	L-O.	W. N.	G. W.	TOTAL.
No. 1	6	—	—	—	—	—	6
No. 4	8	—	—	8	7½	6	29½
No. 6	—	9	6	9	—	—	24
No. 10	6	—	—	10	6	—	22
No. 12	—	5½	8	7	—	7	27½
No. 13	6	7	7	—	—	5	25
No. 17	—	5½	—	—	5	—	10½
No. 18	10	10	9	6	9½	9	53½
No. 20	—	—	—	—	7½	—	7½
No. 24	—	8	10	5	—	10	33
No. 26	9	—	5	—	9½	8	31½

The main gap in this list evidently comes between Nos. 10 and 17, whereas Nos. 6 and 10 come very close to No. 13. I have therefore decided to select the first eight in the score, viz.:—No. 4, "Three Steps and a Shuffle-off"; No. 6, "Trifolium Duplex"; No. 10, "Possibilities"; No. 12, "Ariadne"; No. 13, "Leonard"; No. 18, "Bargany"; No. 24, "Weighty"; and No. 26, "Ben Trovato." The overwhelming preponderance of votes given to No. 18 is the most remarkable feature of the list. Until I come to scale the problems I cannot, of course, say whether it will maintain its lead.

CHESS INTELLIGENCE.

The third International Tournament at Monte Carlo is now in progress. The list of competitors is greatly weakened by the absence of Messrs. Janowski, Lasker, and Tchigorin. It is a two-round competition, the players being Albin, Marco, Maroczy, Marshall, Mason, Moreau, Mieses, Pillsbury, Reggio, Schlechter, Tarrasch, Taubenhaus, Teichmann, and Wolf. As might be expected, Mr. Pillsbury has already obtained the lead, while Maroczy and Teichmann have also made a good start.

We much regret to record the death of Mr. James Innes Minchin, for many years Honorary Secretary of the St. George's Chess Club. Mr. Minchin was, after Professor Wayte, probably the strongest of the regular players in the club, and took a leading part in promoting the International Tournament of 1883.

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CONTENTS.

THE PALÆONTOLOGICAL CASE FOR EVOLUTION.

By R. Lydekker.

At the date of publication of the first edition of "The Origin of Species," in 1859, the poverty of our palæontological collections—especially as regards the remains of vertebrates—the so-called "imperfection of the geological record," and the comparatively small area of the earth's surface which had been geologically examined, were regarded as reasons sufficient to explain the absence of evidence of any one definite line of descent of a modern from an ancient type of animal. In addition to this, it was pointed out that a very large percentage of the fossil vertebrates then known to science were represented by such fragmentary remains that it was almost, if not absolutely, impossible to arrive at any satisfactory estimate of their real affinities and relationships; and it seems to have been taken for granted that there was comparatively little hope of matters being materially mended in these respects in the near future. Moreover, the suggestion was hazarded* that one living mammal might be the descendant of a second, and that possibly the horse might trace back its ancestry to the tapir. Not a shadow of suspicion seems indeed to have existed at that time in regard to the ancestry of the horse (or, as we should properly say, the horse tribe), although, curiously enough, the chief stages in that line of evolution were already known to science.

Matters remained in much the same state till at least as late as the issue of the fifth edition of "The Origin of Species" in 1869. Twenty years later, however, when another important work on the same subject—Dr. A. R. Wallace's "Darwinism"—made its appearance, evolutionists were able to bring forward a much more formidable array of evidence in favour of their doctrine, especially in regard to vertebrates. During the two decades which had elapsed since the publication of the fifth edition of Darwin's great work, the marvellous discoveries in vertebrate palæontology made by Marsh and others in the north-western territories of the United States had come as a revelation to the zoological world; while the enormous number of mammalian remains brought to light during the working for commercial purposes of the valuable deposits of phosphorites in Central France had served to revolutionize our conceptions of the extent and relationships of the ancient Tertiary mammalian fauna of Europe. Marsh, ably seconded in this country by Huxley, had also been enabled to work out in detail the ancestry of the modern horse and its relatives (though the identity of the earliest member of the series with the little hyracothere discovered more than forty years previously in the London Clay was still unsuspected); and the descent of the modern rhinoceroses from primitive types of odd-toed mammals had likewise been demonstrated. Huxley, too, had made known the existence of many remarkable resemblances between the skeletons of birds and those of the extinct dinosaurian reptiles; while his account of the relationships of the ancient to the modern crocodiles afforded an important piece of evidence in favour of the evolution of animal forms.

It was still, however, a matter of reproach to those who supported the doctrine of evolution that so few phylogenies, or lines of descent, could be cited as firmly established on palæontological evidence. Huxley had indeed insisted (perhaps with rather too much emphasis) on the intimate relationship formerly existing between birds and reptiles on the one hand, and between salamanders and fishes on the other, but practically nothing had been learnt with regard to the affinities between mammals and other groups of the vertebrate stock. Again, the modern type of bony fishes were believed to have made their appearance suddenly in the Cretaceous epoch, and to have no connection with the earlier mail-clad fishes commonly called ganoids; although, it is true, the suggestion occurs in Dr. Wallace's book that certain reputed members of the latter group might prove to be much more closely related to the bony fishes than was commonly considered to be the case.

Since 1889 our knowledge of the mutual relationships of different groups of vertebrates, and of the phylogeny of particular families, as deduced from their fossil remains, has increased by leaps and bounds And, so far as the specimens in our museums are concerned, we are now suffering from an *embarras des richesses* rather than from lack of material.

So far as we are aware, no attempt has been made of late years to lay before the general public in a popular manner some of the most striking features of the case for evolution as presented by palæontological evidence.

* *See* Fifth edition, page 347.

Although this is by no means an easy task, so far as vertebrates are concerned, it is the object of the present article. As regards the phylogeny of particular family groups of animals, attention is chiefly concentrated on mammals—the highest of all animals—but the subject would manifestly be incomplete without some reference to the evidence as to the mutual relationship of the primary groups into which the vertebrata are divided by naturalists. It is this portion of the subject which claims our first attention.

With regard to the evidence in favour of a genetic connection between vertebrates and lower forms of animal life commonly termed invertebrates, opinions at the present day are so divided and so little is known with certainty, that any lengthened discussion on this aspect of the subject would be unprofitable. It may be mentioned, however, that in the far distant epoch when the Old Red Sandstone of Scotland was being deposited there flourished in the lakes and rivers of the northern hemisphere a group of mail-clad, somewhat fish-like creatures of which the two leading types are collectively known as cephalaspids and pteraspids. A striking feature of these lowly creatures, and the one from which the former group takes its name, is the presence of a large shield covering the head-region, and in some cases taking somewhat the form of a cheese-cutter. Now this shield has a curious resemblance to the carapace, or shell, of a remarkable little freshwater crustacean known as *Apus*, which may be met with in ponds in this country. This resemblance is regarded by some palæontologists—Professor Patten among the number—as not due to accident (if we may use the expression), but as indicative of a true genetic relationship between the two groups. And the writer whose name is cited in the last sentence would even go so far as to say that we are justified in regarding vertebrates and arthropods (crustaceans, insects, etc.) as diverging branches of a common ancestral stock closely related to the cephalaspids. Whether this striking theory will be confirmed, or otherwise, time alone will show, but it serves to indicate that there is at least some kind of palæontological evidence in favour of the origin of vertebrates from lower types of animal life. Nor are others wanting, although space and other considerations do not admit of their discussion on this occasion.

We pass on, then, to consider the evidence in favour of the descent of mammals from lower types of the vertebrate stock.

Till comparatively recently it was supposed that salamanders—not the living forms, but their presumed ancestors, the labyrinthodonts of the Carboniferous and Permian epochs—were the nearest relatives of mammals, and, on the evolution hypothesis, the representatives of the parent stock from which the latter group originated. This idea was in great part due to the circumstance that while in reptiles (as in birds) the skull is articulated to the first joint of the backbone, or vertebral column, by a single knob—technically termed the condyle—in mammals and salamanders there are two such knobs or condyles. The single reptilian condyle consists, however, of three parts, a median and two lateral elements, as is well shown in the back view of the skull of a turtle. Now it is evident that by the loss of the median element, and the extra development of the two lateral parts, such a tripartite single condyle could quite easily be converted into the double condyles characteristic of mammals; and, as a matter of fact, there are indications how such a transformation has been actually brought about.

The possibility, or indeed the very existence of such a transformation would not, however, be sufficient to demonstrate the descent of mammals from reptiles. To prove this we have to rely upon the evidence afforded by a remarkable group of extinct reptiles which flourished during the early portion of the Secondary epoch of geological history, and attained a special development in South Africa, or at all events, have left a large series of their remains in that country. One of the most curious things about these anomodonts (or theromorphs), as they are called, is the similarity of their teeth to those of carnivorous mammals; the division into incisors, canines, or tusks, and cheek-teeth, or grinders, being just as well developed as in the latter. But it is not on this dental evidence, strong as it is, that we have alone to depend in affiliating mammals to anomodonts. In the first place there are certain very significant resemblances between the skulls of the two, more especially as regards the structure of the region of the cheek-bone. Of even more importance is the community of structure displayed by the bony girdles supporting the limbs of the anomodonts and the same portion of the skeleton in the living egg-laying mammals of Australia. In each, for instance, the haunch-bone consists of three precisely similar elements; and an equally remarkable resemblance is displayed by the shoulder-blade and the bones connected with the same in the two groups. It is not easy to make those unacquainted with anatomy thoroughly realise the importance of these structural similarities; but to the anatomist they are full of significance, and proclaim with no uncertain sound the existence of an intimate genetic relationship between the ancient anomodont reptiles and the modern monotreme mammals.

Dr. H. Gadow, of Cambridge, sums up the case concisely, as follows:—"Mammals," he writes, "are descendants of reptiles, as surely as the latter have been evolved from amphibia (salamanders and their kindred). This does not mean that any of the living groups of reptiles can claim this honour of ancestry, but it means that the mammals have branched where the principal reptilian groups meet, and that is a long way back." The anomodonts, or theromorphs, he adds, and especially the smaller representatives of the sub-group known as theriodonts, alone show us what these primitive—half reptile, half mammal—creatures were like.

But, it may be objected, the most mammal-like of these generalised reptiles were furnished with a full series of formidable teeth simulating those of the carnivora, whereas one of the two existing representatives of the egg-laying, or monotreme, mammals, namely the spiny ant-eater, is toothless, while the other (the duckbill, or platypus) has only a few teeth on the palate in early life, and these of an altogether peculiar and aberrant type. There can, however, be little doubt that some, at least, of the ancestral mammals were provided with a full series of differentiated teeth like those of the carnivorous anomodonts, although it is by no means certain that the modern egg-laying mammals are derived from such a type. Among the anomodonts, for instance, there occur certain forms with teeth not very unlike those of the duckbill, and it is thus quite possible that the latter animal and the spiny ant-eater trace their descent to a special branch of the anomodont reptiles.

For the ancestors of mammals other than the modern monotremes we may not improbably look to the small forms of which a few jaws have been met with in the Stonesfield Slate of Oxfordshire. That these early mammals were the direct descendants of the anomodonts there can be little hesitation in admitting; and it is also quite within the bounds of probability that they laid eggs. Unfortunately, however, our knowledge of these Jurassic mammals is of the most vague and unsatisfactory nature; this being mainly owing to the extreme rarity and frag-

mentary condition of their known remains. Possibly this may be accounted for on the supposition that the evolution of primitive and presumably egg-laying mammals from anomodont reptiles did not take place in Europe, or indeed anywhere in the northern hemisphere; so that the few remains with which we are acquainted were probably derived from individuals which had strayed far away from the headquarters of the group. Nothing is indeed more likely than that Africa was the region where the anomodonts developed into egg-laying mammals; and it is to that continent more than to any other part of the world that we may look with the most hope to the discovery of a full series of the intermediate forms between reptiles and mammals.

There is, indeed, a very great and very serious "imperfection of the geological record" in regard to the origin of mammals. For after leaving the rich anomodont fauna of South Africa, nothing is known of mammalian development and history save such imperfect information as can be gleaned from the aforesaid jaws from the Stonesfield Slate, and others from the Purbeck deposits of Dorsetshire, and the Triassic, Jurassic, and Cretaceous rocks of the United States, till the early part of the Tertiary period is reached. Then we come suddenly upon an abundant and well differentiated mammalian fauna widely spread over the northern hemisphere. The immediate ancestors of this fauna we have yet to find.

Nevertheless, in spite of this very large gap in our knowledge, the information we already possess is, as mentioned above, amply sufficient to demonstrate the close affinity existing between mammals and the anomodont reptiles, and to justify the assertion that (if evolution be the true explanation of animal resemblances) the one group is the descendant of the other. The thread of mammalian development will be taken up again in a later paragraph; but before this is done, a few words must be devoted to the other main groups of mammals.

In the passage from Dr. Gadow's paper quoted above it is incidentally mentioned that as reptiles have given origin to mammals, so they themselves are the offspring of amphibians, or salamanders. And here, somewhat curiously, we must once again refer to anomodonts. Among the more mammal-like types in this group the skull is vaulted, with the temporal region open, and the component bones smooth, while the limbs were elongated and adapted to raise the under surface of the body well above the ground. On the other hand, there are certain members of the group in which salamander-like features predominate, the skull being depressed and expanded, with the temporal region roofed over, and the cranial bones sculptured externally, the limbs being short, so that the under side of the body touched the ground.

We thus have an approximation between the anomodonts and the primeval salamanders, or labyrinthodonts, although the exact nature of the relationship is at present somewhat obscure. The labyrinthodonts, or, as they are often called, stegocephalians, display, however, an almost complete passage into reptiles; so much so, indeed, that certain American Permian forms (*Eryops* and *Cricotus*) are placed by some writers in the first group and by others in the second. Among the most salamander-like of true reptiles are certain small forms (such as *Hylonomus*) from the Carboniferous and Permian; these in their turn pass into still more advanced types, such as *Protorosaurus* of the upper Permian, and *Palæohatteria* of the Trias, and from these latter there is an almost unbroken transition to the New Zealand tuatera lizard (*Sphenodon*), by far the most primitive and generalised of all living reptiles.

Regarding the connection between salamander-like amphibians—more especially the labyrinthodonts, or stegocephalians—and fishes on the one hand and reptiles on the other, we may once more, with slight verbal alteration, quote from Dr. Gadow,* who writes as follows:—"There is no doubt that the Amphibia have sprung from fish-like ancestors, and that they in turn have given origin to the Reptilia. The Amphibia consequently hold a very important intermediate position. It was, perhaps, not a very fortunate innovation when Huxley brigaded them with the fishes as Ichthyopsida, thereby separating them more from the Sauropsida (reptiles and birds) than is justifiable—perhaps more than he himself intended. The connecting link, in any case, is formed by the Stegocephalia; all the recent orders, the burrowing cæcilians, salamanders and frogs, are far too specialised to have any claims to the direct ancestral connections. The line leading from the Stegocephalia to fossil reptiles, notably to such Proreptilia as *Eryops* and *Cricotus*, and even to the Prosauria (*Hylonomus*, *Palæohatteria*, etc.), is extremely gradual, and the steps are almost imperceptible. Naturally, assuming evolution to be true, there must have lived countless creatures which were neither Amphibia nor Reptilia in the present intensified sense of the systematist. The same consideration applies equally to the line which leads downwards to the fishes. But the great gulf within the Vertebrata lies between fishes and Amphibia, between absolutely aquatic creatures with internal gills and 'fins,' and terrestrial quadrupedal creatures with lungs and fingers and toes."

Since, as indicated in the closing sentence of this passage, direct palæontological evidence of the descent of salamanders from fishes is at present wanting, we shall say no more with regard to those groups, except that the indirect evidence, as Dr. Gadow points out, is of itself sufficient to indicate the former existence of intermediate types. We accordingly pass on to the fourth great group of vertebrates, the birds.

That modern birds come closer to reptiles than to any other vertebrates is indicated by Huxley's scheme of brigading the two groups together under the common title of Sauropsida, to which allusion has been already made in this article. To describe their common features in detail would be quite out of place on the present occasion, but it may be pointed out that both groups agree in having a single condyle on the skull for articulation with the first segment of the backbone, as well as in the ankle-joint being situated in the middle of the tarsus instead of at the upper end, and also by the frequent presence of what are called uncinate processes to the ribs, and of a ring of bony plates in the white of the eye. A certain approximation to the reptilian type is, moreover, made by the lizard-tailed birds (*Archæopteryx*) of the Jurassic strata in the retention of the long tail from which they derive their popular title, as well as by the presence of claws on two of the digits of the wing, and of teeth in the jaws; teeth being also retained in several, if not all, of the birds of the succeeding Cretaceous epoch. Nevertheless, *Archæopteryx* is in all respects essentially a bird, and in no sense an intermediate form between birds and reptiles.

There are, however, certain extinct reptiles, the Dinosauria, many of whose members habitually assumed an upright posture, which exhibit much more decided structural resemblances to birds than are presented by any modern reptiles. One of the most remarkable of these resemblances occurs in the bones of the hind-leg, in which the upper part of the ankle, or tarsus, tends to unite itself with the leg-bone, or tibia, thus simulating the tibio-tarsus, or leg-bone of a bird. On the other hand the lower half of the tarsus displays an equally marked

* "Cambridge Natural History—Amphibia and Reptiles," p. 5.

tendency to coalesce with the upper bones of the foot. Nor is this all, for the latter bones—the metatarsals of the anatomist—in some cases are partially coalesced, so as, in conjunction with the lower half of the ankle, to approximate to that very characteristic bone of a bird's leg the tarso-metatarsus. Moreover, there are decided resemblances between the haunch-bones, or pelvis, of dinosaurs and birds.

It was largely on the evidence of the dinosaurian skeleton—especially that of some of the smaller members of the group—that Huxley was induced to brigade birds and reptiles together as Sauropsida. When this generalisation was made, the modern doctrine of parallelism in development was not recognized as an important factor in evolution; and since its recognition doubts have been expressed whether the skeletal resemblances between birds and dinosaurs may not be due to this cause rather than to direct genetic affinity between the two groups. By parallelism in development, it may be explained, is meant the production of more or less nearly identical structural peculiarities by adaptation to similar, or somewhat similar modes of life; or perhaps, in some instances, to a general progressive evolution towards a higher structural type. One of the best instances is afforded by the cases of the horses and the prototheres, to which attention is devoted in the sequel.

With a full knowledge of the important part played by parallelism in development before him, Prof. H. F. Osborn,* of New York, has recently reconsidered the evidence in favour of the existence in the Permian period of a common ancestral stock from which have diverged dinosaurs and birds. While admitting that many of the resemblances between these groups are adaptive rather than genetic, and believing that the apparent close correspondence in the structure of the pelvis between adult birds and the herbivorous dinosaurs (which are specialised types) is due in a considerable degree to a misinterpretation of the homology of some of their elements, Prof. Osborn nevertheless argues that the resemblances between the two groups are so numerous as to justify the belief of kinship. Special importance is attached to the opinion that some sort of bipedalism was a common character of all dinosaurs, the suggestion being countenanced that certain forms, like *Stegosaurus*, have reverted from a bipedal to a quadrupedal mode of progression. Our present knowledge, he concludes, therefore, justifies us in saying that "in this bipedal transition, with its tendency to form the tibio-tarsus, the avian phylum may have been given off from the dinosaurian. This form of the Huxleyan hypothesis seems more probable than that the avian phylum should have originated quite independently from a quadrupedal proganosaurian [prosaurian] reptile, because the numerous parallelisms and resemblances in dinosaur and bird structure, while quite independently evolved, could thus be traced back to a potentially similar inheritance."

Although to the lay reader his mode of expression may appear somewhat unnecessarily technical and abstruse, if not, indeed, in certain respects, absolutely cryptic, there is no doubt from the foregoing observations that Prof. Osborn inclines to the belief that birds are in some manner genetically connected with the dinosaurian reptiles, although, from the existence of fully differentiated birds at such an early epoch as the upper Jurassic, the date of divergence must have been extremely remote, possibly as far back as the Permian.

Before leaving this portion of the subject, a word is advisable with regard to the flightless birds of the ostrich group. Not very many years ago it was considered that this group was the oldest and the one nearest akin to the extinct dinosaurs. It is now, however, quite evident, if only from the structure of their degenerate wings, that the ostrich-like birds, in place of being their ancestors, are themselves descended from forms endowed with the power of flight—whether from more than a single group we need not now pause to enquire. It is true that in certain respects their skeletons come nearer to the dinosaurian type than is the case with those of their flying relatives. But their resemblance—either by parallelism in development, or by reversion to the common ancestral type—may probably be explained by their mode of life being more like that of dinosaurs, and perhaps in part by the large bodily size of the majority of the group.

(*To be continued.*)

* *American Naturalist*, October, 1900.

LORD KELVIN'S NEW IDEA ABOUT ETHER ATOMS.

By Dr. J. G. McPherson, F.R.S.E.

Lord Kelvin, President of the Royal Society of Edinburgh, startled the Fellows, on the evening of the 19th January, with his new idea about ether atoms, in his exposition of the reflection and refraction of light. He has been for years met by serious difficulties in carrying out the practical conclusions of the undulatory theory of light; and these difficulties he exposed in detail.

One investigator after another he found to make ingenious suggestions on the old lines. But Fresnel, Green, Voight and others, with all their ingenuity, could not account for certain discrepancies. But Lord Kelvin, with a master hand, has dispelled all these difficulties by a direct denial of a tenet of the Schoolmen that "two bodies cannot occupy the same space at the same time." Paradoxical as it appears, he assumes the opposite, that two bodies can occupy the same space. That is his main and fundamental tenet, and by it he is able to clear the air of what, for a quarter of a century, has interfered with his coming to satisfactory conclusions on light and electricity.

Leucretius was right in saying, two thousand years ago, that matter was not infinitely divisible, but that atoms and the void constituted matter. These atoms, he considered, were indivisible, originally moving in parallel lines. His fallacy was in assuming that an atom had the inherent *facul* of changing the direction of its motion, so that, by interrupting the parallel lines of motion of the atoms by the alteration of direction at some point, atoms were brought together out of the void to form matter. Yet Leucretius did not dream with his fallacy; for Lord Kelvin, though discarding any idea of the quasi-living power of the atom to change the direction of its motion, assumes that there is an *electrion*, or electric atom within the material atom.

Lord Kelvin assumes that, *prima facie*, according to the laws of dynamics, the material atom is of a spherical form. But this atom is permeated by the ether atom, both occupying the same space. Though the electrion is not material, the ether atom is material, of the fine jelly constituency, infinitely incompressible, though easily changeable in form.

He illustrated the combination of the ether and ordinary material atoms in one spherical form and place by simple experiments. If a piece of common shoemaker's rosin be hung in water, and an iron bullet be placed on the top surface of the hard rosin, the bullet will, through time, slip inside the rosin. If, again, a spherical piece of cork be placed under the rosin, it will work its way up into the rosin, just as the iron bullet wrought its way down.

Two indivisible bodies cannot; two divisible bodies

The spherical atom of matter is not homogeneous, but it is heavier at the centre than near the surface. Accordingly, when an ether current comes upon the spherical surface of the material atom it acts differently from the case of coming upon an ether atom. In the latter case, it would pass right through without change of direction. In the former case, the direction of motion would be attracted for a time nearer the centre of the atom, on account of the greater density there, and again reach the opposite side of the sphere, finally issuing from the surface of the sphere in the original direction of motion.

The electrion is the marvellous worker in the atom of matter, permeated by the ether atom. It is not always a unit, it may be one, two, or more, but up to nine will account for all the variations of motion, in unstable circumstances; yet there may be hundreds all within the one material atom. Nine he considers the necessary maximum, though one may, in certain circumstances, suffice. This electrion, with the self-occupancy of the ether atom and material atom, is the new means which he has secured for explaining away the difficulties which he has for long experienced in accounting for certain details in polarized light.

This is a bold stroke, and we must wait with patience until his remarkable paper is published, in which he gives startling details to undermine much of what has been done by writers on Light. He holds to Newton's law of gravitation, that one body influences another body, though not in contact, but he requires his new idea of the combination or self-occupancy in the same space of the jelly-like ether atom and the spherical material atom.

Even this outline must interest our readers. Without diagrams, and these would be imperfect, I could not give them an accurate idea of the facility of the explanation of the undulatory theory of light in reflection from a perfectly polished silver plane, and in refraction through the diamond, ordinary glass, and water. These Lord Kelvin illustrated by curves, showing the inaccuracy of the curves made by former observers and the accuracy—as tested by experiment—of the results of his hypotheses.

CROSS-FERTILISATION IN SOCIOLOGY.—II.

By J. Collier.

Individual Fertilisation.

Immigrant individuals initiate or continue the work of groups or masses. A few striking examples may be as convincing as a long list. Dynasties are often founded by immigrants. A Suabian cadet founded the house of Hohenzollern, and his type of character has proved persistent through all alliances, manifesting itself as plainly in the present vigorous ruler as in any of his ancestors. By a kind of moral transfusion the solid qualities of the race have passed into the people, which is likewise marked by courage, prudence, thrift, simplicity of life, a firm grasp of reality, and a total estrangement from German dreaminess and confused vision of reality. With these attributes kings and people together have expanded a slender nucleus into a powerful state, and made that state the heart and brain of Germany. A single woman carried into France in the sixteenth century the impure blood of the Medici. Keen observers have detected in the portraits of her sons the prepotency of the strong Italian house over the brilliant lineage of Francis I. Is it possible to mistake the same prepotency in the history of the following reigns? At a time when France was wavering between Catholicism and the Reformation, Catherine and her sons assured the predominance of the old religion. Corsican Napoleon re-made France in his own image. The Cisalpine house of Savoy built up the Transalpine kingdom of Italy. Noble families, too, have introduced a new strain into their adopted country. The German Colonnas in Italy were long and strenuously anti-Papal; the Savoyard Colignys nearly succeeded in carrying France over to Protestantism; the Italian Broglies, though doubly crossed with Protestant houses, have, on the whole, exercised a reactionary influence in France; the Savoyard Sainte-Aldegonde was the author of the Compromise of Breda with which began the war of independence in Holland; and another Savoyard, Bonnivard, heralded the reformation in Switzerland, and the independence of his country. Great statesmen have sometimes given a new political complexion to their adopted country. Mazarin saved the unity of France. Beaconsfield added prestige to Imperialism, and created a new England that some of us no longer know. The Duc de Richelieu was the founder and ruler of Odessa. Bolivar was no Peruvian. Political leaders, such as Kossuth and Strossmayer, were foreigners. Great discoverers, from Columbus to De Brazza, are often foreigners. Four Danes excited original developments in Prussia. Repaying the debt of France to Maurice of Saxony, Moltke made advances in the art of war that assured victory to Prussia and afterwards to Germany. Niebuhr created a new historical method, to which Mommsen gave ascendency. George Brandes has acclimatised cosmopolitan criticism in Berlin. The arts have everywhere been transmitted by immigrant artists. Two examples will perhaps serve where hundreds could be given. Lulli, with the aid of Quinault, founded Italian opera in France, and from their joint product descends the characteristically French opera, Gounod's "Faust." Spontini carried Italian melody to Germany, and there married it to the German genius for harmony, represented by Weber, and from these two have sprung Mozart's "Don Giovanni," and the more characteristically German operas of Wagner. An equally pointed instance will show how cross-fertilisation acts in science. The Italian astronomer, Cassini, made in Paris the first observations for measuring the earth. In company with the Abbé Picard he began the tracing of the first meridian, which Picard continued, and from the measurement of the degree given by Picard, Newton calculated the force that retains the moon in her orbit. The more recent names of Tadema and Herkomer, of Panizzi and Libri, Mohl and Max Müller, out of hundreds in all countries, will suggest how much all departments of human activity are fertilised by blends. Sometimes immigrants merely strengthen an existing tendency. The Saxons Ranke and Treitschke, transplanted to Berlin, became "more Prussian than the king," and the Suabian Hegel buttressed Conservatism in the same country. Lastly, prelates like Bessarion and Ximenez, and such monarchs as Francis I. and Louis XIV., Isabella of Spain and Catherine dei Medici, the Czar Peter, the Czarina Catherine, and Frederick the Great, who import artists, men of letters, and savants, resemble the botanists who place the pollen of one plant on the stigma of another, or the breeders who artificially pair varieties.

Degenerate Modes.

We have already passed insensibly into a new order of facts. Fertilisation by masses and groups was brought about by the actual mingling of two stocks. Fertilisation by individuals is often physical; the Colignys and the Colonnas, the Savignys and Chopins, the Roscoes and Rossettis, are the offspring of crosses between immigrants and natives. But many immigrants of genius are either celibate or sterile. Mazarin, Disraeli, and Moltke were

see I am not the [illegible] who sees [illegible]

pure-bred, and though all three left behind them offshoots of their race, they themselves added not a drop of alien blood to their adopted countries, any more than did the host of missionaries, from Mahinda and Boniface to Moffat and Damien, to the countries they evangelized. Their action was purely spiritual. Spiritual action is the mimicry of physiological action; nevertheless, it too is genuine. A thinker's thoughts, an artist's works, a statesman's deeds, are as children born to him, and the transformation they accomplish becomes physiological in turn. The modes of cross-fertilisation still to be described are of this order.

The female of many animal species goes in search of the male, or at least throws herself in his way. From Plotinus to Postel, and from Burnouf to Mrs. Besant, sages, scholars, and seekers have gone on pilgrimage to the East to discover the secrets of existence or the materials of science. Mediæval students flocked to Paris, and the fertility of Scholasticism is doubtless due to the German, Italian, and English crosses with the French intellect. Young Castilians southed to Granada to learn courtly manners, as the young English used to do the grand tour, and Spanish ceremony may owe its stateliness to the instruction. The English, French, and German scholars of the Renaissance pilgrimed to Italy. Painters and sculptors of all countries frequented Rome, as now Paris. New species are thus begotten. Again a few examples must suffice.

Almost all the pre-Revolutionary thinkers of France had visited England, and had studied its constitutional liberties, its science, philosophy, and free-thought. Montesquieu spent two years in our country, and every page of his chief work bears witness to the fertility of the contact. Voltaire came to England "to learn to think," and passed three years in constant intercourse with its greatest writers. His debt to English thought has perhaps been overstated. M. Brunetière has conclusively shown that Voltaire's scepticism was of earlier date than his visit to England, and in fact he but continued an old French tradition. But it cannot be doubted that his native tendencies were stimulated by acquaintance with Bolingbroke and English deists. Not less fruitfully he became the expositor of the Baconian logic, the Newtonian physics, and the Lockian psychology. English notions of liberty and canons of criticism passed into the French mind. Mr. Lecky does not exaggerate in describing this interaction as the junction of the French and English intellects.

The Baptist of the modern renaissance of art was Johann Joachim Winkelmann. A deep affinity for Hellenism in both intellect and temperament led him to the study of Plato, the inspection of casts from the antique at Dresden, and finally to Rome. There he accomplished his "finding of Greek art." All who have since transfused the old Hellenic spirit into literature and faith, art and life, descend from him. No more scientific language than Hegel's can be used to describe his generation of a new variety:—

> "By contemplation of the ideal works of the ancients, Winkelmann received a sort of inspiration through which he opened a new sense for the study of art. He is to be regarded as one of those who in the sphere of art have known how to initiate a new organ for the human spirit."

Under the grey skies of Sweden, Fogelberg, like Mignon, dreamed of the South. A dying Swedish sculptor told him that in Italy alone he should find true beauty. He had sought to achieve a Balder, a Thor, an Odin, and had failed; he needed the fertilising contact with Greek art. After some years' study in Italy he produced an *Odin*, which Gustave Planche describes as the offspring of "a happy alliance between the Swedish genius and the antique genius." It is a new type, a genuine creation. His *Thor* and *Balder* are similarly two original types, neither Greek nor medieval, whose conception is Scandinavian, while the expression is Greek.

Thorwaldsen spoke of himself as having been born on the day he entered Rome, when he was twenty-seven years old; till then, he said, he did not exist. The influence of Rome transformed a skilled artisan into a sculptor. His principal merit, according to Vicomte Delaborde, lay in combining the ancient style with modern sentiment. He expressed modern ideas and new or revived themes according to Greek methods, discovered by intuition and not by learning. He went back to an earlier period of Greek art than had previously been imitated, and, with an irresistible force of assimilation, he incorporated its substance and penetrated its spirit. Michel Agniolo had, in just the same way, founded the sculpture of the Renaissance. More consciously and systematically, Flaxman and Ingres arrived at similar results.

The extent to which this mode of cross-fertilisation still prevails in scholarship will appear from the fact that, in 1900, over 2500 foreigners were entered on the books of German universities. Of these 736 were Russians, in whom the ardour of conquest is equalled by the ardour of discipleship. The Russians are at once female to higher and male to lower races.

Secondary Agencies.

1. The insects, birds, and mammals that carry pollen and seeds to other plants and countries, have their analogues in the chapmen and travelling merchants, navigators, pilgrims, and missionaries, who convey books, works of art and industry, germs of religious ideas and political movements. It is a degenerate mode of fertilisation, being far slower and less efficacious than the local presence of immigrants, but its effects are identical. Native species are modified, if less deeply, and new species are transplanted, though they, too, undergo modification. An ancient and a modern example may be adduced. Phœnician merchants undesignedly introduced into Greece the Egyptian alphabet and art of writing, and thus founded the culture of Europe. The first seeds of Christianity were planted, half unconsciously, by the pirate-merchant Vikings, who returned to Scandinavia after a long sojourn in Christian lands.

2. The winds and marine currents that likewise transport seeds have their congeners in the world-rivers and commercial routes, and their analogues in the ships, caravans, and vehicles by means of which the bulk of modern propagandism is accomplished. Wind-fertilised plants are believed to be degraded specimens of insect-fertilised plants, and the intellectual influences conveyed through books and casts, though often vivid and powerful, are faint in comparison with the direct action of teachers immigrant or resorted to. Two illustrative instances might be developed were there space:—(1) New England transcendentalism was begotten by the writings of Coleridge, Cousin, and Carlyle on the theology of Puritanism as expounded by profound thinkers like Jonathan Edwards. None of its inspirers ever visited America, and, if Emerson visited Coleridge and Carlyle, he professed that he derived little benefit from personal intercourse with either of them. Yet New England transcendentalism is a distinct variety of philosophic thought. (2) Darwin never visited Germany, and few Germans were received at the modest house in Down; yet Darwin's writings initiated a new and fruitful movement in that country to which no bounds can be set. Darwinism developed by Haeckel is, again, a distinct variety.

From these few examples alone we might conclude that "nature abhors self-fertilisation" in civil as in natural history, and that no sociological species, as no biological species, is perpetually self-fertilised. Where a nation, like the Chinese, maintains its vigour intact for centuries of refusal to cross, it owes its tenacity to being one of the most widely migratory peoples on record. Dispersal over a large area may protect a species against its own exclusiveness.

THE CHEMISTRY OF THE STARS.

II.—VARIETIES OF SPECTRA.

By A. Fowler, F.R.A.S.

The first recorded observations of the spectra of the stars and planets were made in 1814 by Fraunhofer, who then discovered the important facts that Venus and Mars had spectra resembling that of the sun, while the spectrum of Sirius was very different. After increasing his previously very small optical equipment—a prism of 60° in front of the telescope of a theodolite—it was found that the spectrum of Castor was like that of Sirius, the spectra of Capella and Pollux similar to the spectrum of sunlight, and the spectrum of Betelgeuse somewhat different. Fraunhofer, in short, recognised that there were at least three varieties of stellar spectra.

It was not until 1859, however, that these observations received the notice to which they were entitled. In that year Kirchhoff published his researches on the origin of dark lines in spectra, and it soon became evident that the methods employed in the analysis of sunlight could be equally applied to the determination of the chemical constituents of the stars. Rutherfurd, Secchi, and Sir William Huggins were most prominent among the earlier workers in this direction, and while the latter observer chiefly concerned himself with the minute analysis of a few stars, the others observed a greater number of stars with a view to their classification into groups. Following up this pioneer work, detailed investigations of the spectra of the stars have been carried on with conspicuous success by Prof. Pickering in America, Sir Norman Lockyer, Sir Wm. Huggins, and Dr. McClean, in England, and Professors Vogel and Scheiner in Germany.

As a general result of the work which has been done, it is found that the great majority of the thousands of stars which have been studied either fall into one of the types recognised by the earlier observers, or may be considered as intermediate between two of the types; that is, the different varieties merge into each other by almost insensible gradations. For this reason it is now generally believed that stars are not fundamentally different in chemical composition, but that the differences in their spectra are mainly due to differences in the physical states which the stars have reached in an evolutionary process.

In classifications of stellar spectra, an attempt is accordingly made to indicate the order in which the various spectra succeed each other in the history of a star, and not merely to put similar stars into the same group. There are some points, however, on which authorities differ, though there is a general agreement in regard to some of the principal types; and it is doubtless because of the divergencies of opinion that the classification suggested by Secchi, with slight additions, is even now the only one which can be considered an universal language of the subject. It is, in fact, still a very convenient classification so far as concerns the observations which can be made visually, though it is hopelessly inadequate to deal with the finer differences of spectra revealed by modern photographic methods. There is one feature of Sir Norman Lockyer's classification which has much to recommend it as a tentative nomenclature for the greater number of groups which must now be separately distinguished. In this, the various groups are no longer denoted by a distinctive number or letter, but by a name derived from that of a typical star, a plan which had been previously adopted in a small way by other writers; thus if a star gives a spectrum like that of Sirius, it is called a *Sirian* star; if like Antares, an *Antarian* star; if like 19 Piscium, a *Piscian* star, and so on. This nomenclature has the advantage of admitting of easy extension as future researches may require, without disturbing any arrangement of numbers or letters.

It is proposed to discuss later the more important varieties of spectra in some detail, but meanwhile it will facilitate matters to take a broad general review of the various types. In the light of our present knowledge, the classification of Secchi may be conveniently extended as follows, retaining his enumeration so far as it goes, and indicating the varieties of each which have been separately named by Lockyer:—

Type O.—Spectra in which the dark lines of hydrogen and helium are of moderate intensity and nearly all other lines relatively feeble.

From their frequent occurrence in the constellation Orion, the stars of this type are often called "Orion stars," but they are by no means confined to that part of the heavens.

"Helium stars" is a name also sometimes applied to stars of this class.

A few stars of this type, such as γ Cassiopeiæ, show bright lines in addition to the dark ones. These are frequently referred to as stars of the "Orion type with bright lines."

Includes the stars classified by Lockyer, according to differences in detail, as *Alnitamian* (so named from ϵ Orionis), *Crucian* (β Crucis), *Taurian* (ζ Tauri), *Achernian* (α Eridani), *Algolian* and *Rigelian*.

Type I.—Spectra in which the dark lines of hydrogen are very strong and all other lines relatively weak. The weaker lines include both arc and spark lines of various metals.

Includes the groups named by Lockyer *Markabian* (α Pegasi) and *Sirian*. The *Cygnian* (α Cygni) stars may be regarded provisionally as a special variety in which the hydrogen lines are somewhat subdued, while the spark lines of the metals are especially developed.

Type I.-II.—Spectra intermediate between Types I. and II.; the hydrogen lines are of moderate strength, and a great number of metallic lines, both arc and spark, are also conspicuous.

Includes Lockyer's group of *Procyonian* stars. The *Polarian* group, also having numerous dark lines, may be provisionally regarded as a special variety; the hydrogen lines are less intense than in Procyon.

Type II.—Spectra resembling that of the sun, in having a multitude of strong lines corresponding with lines seen in the arc spectra of the metals, the hydrogen lines having lost their predominance. From their resemblance to the sun, the stars of this class are often called stars of the "solar type."

Includes Lockyer's groups of *Aldebarian* and *Arcturian* stars.

Type III.—Spectra with dark flutings, fading towards the red end of the spectrum, and having also many metallic lines. The hydrogen lines are very feeble.

Includes Lockyer's *Antarian* group.

Type IV.—Spectra with dark flutings, due to carbon, fading towards the blue end of the spectrum. All stars of this type are fainter than 5th magnitude.

Includes Lockyer's *Piscian* group.

Type V.—Spectra consisting chiefly of bright lines, some of which are due to hydrogen and helium, and others are at present of unknown origin. On account of the first examples having been discovered by Messrs. Wolf and Rayet, they are often called "Wolf-Rayet stars."

Stars of types O and I. are white, those of type II. vary from yellowish-white to yellow, and those of types III. and IV. range from yellow to red.

An attempt to illustrate the more common spectral types is made in Fig. 5. The spectra are drawn as they appear in prismatic spectroscopes, where the blue end is more dispersed than the red. The spectra of the third and fourth type stars are reproductions of drawings made by Dunér, who has made a special study of these stars.

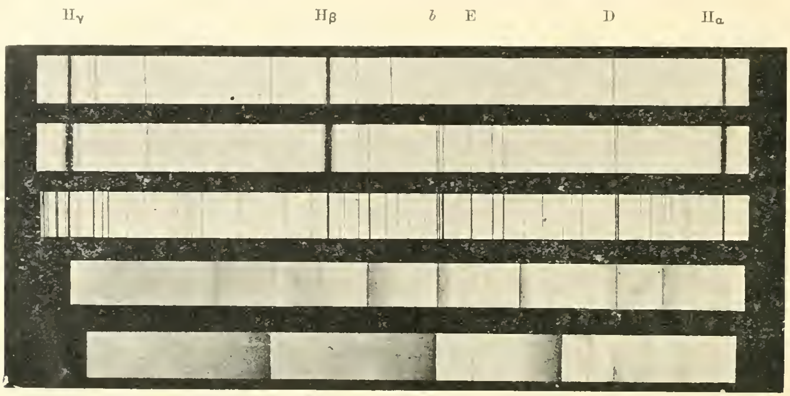


FIG. 5.—The Five principal Types of Spectra. O, γ Orionis; I., Sirius; II., Arcturus; III., α Orionis; IV., 152, Schjellerup.

Remembering that Fraunhofer made *discoveries* with a telescope only a little over an inch in aperture, it will be evident that the observation of the general features of the principal varieties of spectra is possible without any great instrumental equipment, though it must be admitted that it requires a considerable amount of patience. Still, a persevering observer will be well rewarded for his trouble, even if his telescope has no greater aperture than three inches, if he provides himself with a suitable spectroscope.

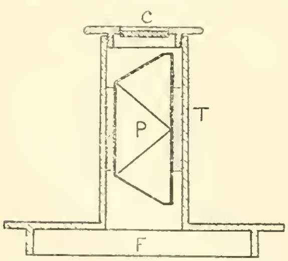


FIG. 6.—The Zöllner Star Spectroscope.

One of the most convenient instruments for viewing the spectra of stars is the Zöllner "ocular" spectroscope, the parts of which are diagrammatically shown in Fig. 6. A small direct-vision prism, P, is inserted in a tube, T, terminating in a flange, F (adapted to fit on the telescopic eyepiece like an ordinary sun-cap), and having a cylindrical lens, C, which comes between the eye and the prism. Suppose that after centering a star in the usual manner in the telescope the spectroscope is added without the cylindrical lens. In place of the ordinary star image a thin line will be seen, red at one end, and passing through all the colours of the spectrum to violet at the other end. Under these conditions the spectrum "lines" are mere dots, and to make them more easily visible it is necessary to broaden the spectrum by introducing the cylindrical lens, so that the dots are spread out into lines. The use of this spectroscope is thus very simple—the star is centred and focussed in the ordinary manner, and then the spectroscope is slipped on the eyepiece, no alteration of focus being required.

Another well-known arrangement is the McClean star spectroscope. Here the cylindrical lens is a concave, and combines the functions of the cylindrical lens with those of the telescopic eyepiece. The cylindrical lens alone, if used as an eyepiece for the telescope, will show a star image as a short line of light, of course without colour, and this is spread out into a spectrum when the prism is added. The procedure with this instrument is first to centre the star in the telescope in the usual way, remove the eyepiece, insert the spectroscope, and push in towards the object-glass until the lines appear properly focussed. When once the focus has been determined it is useful to mark the position of the draw-tube.

Believing that a record of actual experience with small instruments will be useful to many readers of KNOWLEDGE, I have asked my friend, Mr. A. Foote, F.R.A.S., who has devoted much attention to stellar spectra as observed with a 3-inch telescope, to be kind enough to furnish me with a few notes as to what he has been able to observe. In acceding to my request, Mr. Foote writes:—

"I am very glad to supply you with a few selected stars out of a very large list which I have examined with small spectroscopes in my 3-inch telescope. As you are aware, I prefer the Zöllner form of spectroscope, as I found the McClean more difficult to focus. I also found that the McClean did not bring out the solar type stars so well as the Zöllner.

"The stars which give the easiest results to a beginner are those of Type I., in which the hydrogen lines are so prominent. In *Sirius*, the hydrogen lines at F and G (H_β and H_γ) are easily picked up, and are very broad and distinct. *Vega* is perhaps even a

NEBULA INDEX CATALOGUE 405 AURIGA.

By ISAAC ROBERTS, D.Sc., F.R.S.

S.

P.

F.

N.

more typical star of this class, and I think that, on the whole, the two hydrogen lines come out still more distinctly than in the mighty Sirius. Other easy star of this class are *Altair*, *Castor*, *β Arietis*, *α Ophiuchi*, the stars of the *Plough* (with the exception of α and η, which are of different types), and *Regulus*. Stars of lesser magnitude, such as *α Coronæ*, are of course more difficult.

"In stars of the second or solar type, the little instruments will be able to show that there are many sub-divisions of the family. The great *Arcturus* shows many lines, but it is not such an easy spectrum as *Aldebaran*, which gives one of the fullest spectra which can be seen with the means at our disposal. In *Pollux* the lines are finer and more difficult for the beginner, while in *Capella* they are more difficult still.

"Intermediate between these classes comes an easy and beautiful spectrum—that of *Procyon*.

"*Betelgeuse* is perhaps the easiest and best example of the third type; just now it is very beautiful, as the star is so bright. *α Herculis* is more delicately beautiful, but of course is a little more troublesome for the beginner, as it is of considerably less magnitude. *Antares* is very fine, but owing to its southern declination is difficult to get free of atmosphere. *δ Virginis* is pretty beyond words, but is not for beginners. *β Pegasi* is easy and typical.

"The possessor of the small instruments should by all means look at *Rigel* and other bright stars of the Orion type, but he must not be disappointed if he sees no lines! neither will he see much in Spica, which is also of this type; nor, I am afraid, in *α Cygni*, which is a standard spectrum in its way.

"He should also look for the bright C line of hydrogen in *γ Cassiopeiæ*; I have not yet seen it myself, but I mean to!

"A man with these small means must not expect to see everything at the first glance. The hand needs to be trained as well as the eye, as there is no driving clock to keep the stars in the field, but after a little experience the observations are of the greatest possible interest."

PHOTOGRAPH OF THE NEBULA ROUND THE STAR DM. NO. 980, ZONE 34°, IN THE CONSTELLATION AURIGA.

By Isaac Roberts, d.sc., f.r.s.

The photograph annexed delineates the region in the sky between R.A. 5h. 7m. 56s. and R.A. 5h. 11m. 53s., and in Declination between 33° 44′·2 and 34° 48′·0 north. The area, therefore, is 3m. 57s. in extent from *following* to *preceding*, and 1° 3′·8 from north to south. Scale—one millimètre to 15·5 seconds of arc.

Co-ordinates of the fiducial stars marked with dots for the epoch 1900:—

Star (.) DM. No. 978. Zone +34° R.A. 5h. 9m. 18s. Dec. 34° 18′·8. Mag. 7·8.
Star (..) DM. No. 985. Zone +34° R.A. 5h. 10m. 58s. Dec. 34° 8′·2. Mag. 9·2.

The description given of this nebula in Dr. Dreyer's *Index Catalogue*, No. 405, with the names of Schaeberle and Max Wolf, is as follows:—Star 6·7 mag., with pretty bright, very large nebula.

The photograph was taken with the 20-inch reflector, and exposure of the plate during ninety minutes on the 14th January, 1902, and the star referred to in the paragraph above is DM. No. 980, zone 34°. It is involved in the denser part of the nebulosity on the photo-print annexed, at 30 millimètres *south following* the fiducial star (.), but on the negative its image is very clearly shown in the midst of the nebulosity. This condition of obscuration is unavoidable on all copies made from the original negatives, when there is both dense and very faint nebulosity on the same plate, because the faintest stars, the condensations, and structural details in many of the nebulæ, though they are visible on the negatives, cannot be reproduced on copies made from them without sacrificing the relative proportions of the density of the nebulosity as a whole, and thus causing a less accurate perception of the nebula. If we reduce the density of parts of the nebulosity, when making a copy, for the purpose of showing more of the involved details of the structure, the reader should be informed of the fact so that he may not be misled into making erroneous inferences when comparing photographs with each other.

On referring to the annexed photograph it will be seen that the nebula is apparently placed in a crowded field of bright and faint stars in the Milky Way, but we are not warranted in assuming that the normal stars we see scattered over its surface are involved in the nebulosity. There are many star-like condensations in the nebula that doubtless are now undergoing the process of development into stars of the normal type, which, after a lapse of millions of years, may form a cluster of stars such as eye observations and photographs have revealed to us as existing in various parts of space.

The nebula measures about 33 minutes of arc from north to south, and 27 minutes from *following* to *preceding* on the negative. There are extensions of very faint nebulosity on the *preceding* side, beyond the limit of the annexed photograph, but they are too faint for copying. If these were included the nebula would extend to 75 minutes of arc in *north following* to *south preceding* direction, and 54 minutes in *south following* to *north preceding*. This faint nebulosity is of a flocculent character, with broad tortuous rifts in it which trend in diverse directions.

The nebula is one of a class of which we now possess many photographic delineations on a scale sufficiently large for measurements and for scientific investigations, which work we are now and for some time past have been engaged upon.

MAN'S PLACE IN THE UNIVERSE.*

By E. Walter Maunder, f.r.a.s.

Perhaps the greatest drawback under which Science—not one science alone but each and all of the sciences in turn—labours at the present time is the impatience of the general public to receive precise, definite, and striking results. Thus, for example, most popular scientific lecturers find that their audiences look to them to lead up to some clear, crystallised conclusion. It demands some courage, and great skill, to press home upon a popular audience the truth that just in proportion to the advance of our knowledge so is the increase in the number of the problems which are presented to us for solution. The horizon recedes as we advance, and, more than that, it widens at the same time.

A striking example of the eagerness with which the conjecture of a scientific man will be caught up, if only it be sufficiently definite and far-reaching, is afforded by Mädler's celebrated suggestion that the sun with its attendant planets might be travelling in a gigantic orbit of which the focus might be within the group of the Pleiades. In how many thousands of essays, lectures, books, and sermons the statement has appeared that science has proved that the centre of attraction of the universe is located in Alcyone, the chief of the Pleiads, it would be useless to guess. Contradicted a thousand times, the legend seems to have lost none of its pristine vigour. Give a fable a yard's start, and Truth appears to be unable to overtake it in less than a century.

We greatly fear that just such another myth has been started on its career, and by one of the most highly and

* "Man's Place in the Universe, as indicated by the New Astronomy," by Alfred Russel Wallace, d.c.l., f.r.s. *Fortnightly Review*, March, 1903.

most justly honoured of living men of science. The *Fortnightly Review* for March, 1903, opens with an article, at once striking and attractive, on "Man's Place in the Universe, as indicated by the New Astronomy," by Alfred Russel Wallace, D.C.L., F.R.S. The article leads up to a theological application which it does not lie within our province here to discuss; it is the astronomical basis of the article alone with which we are concerned.

Dr. Wallace's first thesis is that the stellar universe is finite in extent and the stars finite in number. His next point is that the proper motions of stars furnish the best indication of their distances. Then he argues that the solar system is about equally distant from all parts of the Milky Way, and exactly in its plane. Then that the sun is one of the central orbs of a globular star cluster, and that this star cluster occupies a nearly exactly central position in the exact plane of the Milky Way. "Our sun is thus shown to occupy a position very near to, if not actually at the centre of the whole visible universe, and therefore in all probability in the *centre* of the *whole material universe*."

This completes the first part of Dr. Wallace's enquiry; the second part deals with the earth's position in the solar system as regards its adaptability for organic life. Here Dr. Wallace leaves strictly astronomical questions and is on his own ground. His point is that the conditions for the development of organic life are far more stringent than has been generally recognised. The surface temperature of the planet must remain stable within a very limited range, not for hundreds or thousands of years, but for millions, perhaps for hundreds of millions. The chief favourable conditions which in their combination appear to have rendered the development of a complex system of organic life possible on our earth are, its distance from the sun securing the equability of temperature just mentioned; an atmosphere of sufficient density; broad and deep oceans, stirred into tides by the action of a large satellite; and the presence of deserts and volcanoes for the distribution of atmospheric dust. The stringency of these conditions appears to indicate that our earth is the only home of organic life within the solar system, and Dr. Wallace considers that suns near the confines of the stellar universe cannot have systems sufficiently stable for their planets to fulfil these conditions there. In his view, therefore, the position of the solar system in the centre of the material universe renders it probable that here, and here alone, has organic life reached its full development.

It will be seen that the entire argument falls to the ground if the first point, the demonstration that our universe is finite, is not complete. As Dr. Wallace himself remarks: "Infinite space has been well defined as a circle, or rather a sphere whose centre is everywhere and circumference nowhere," and unless the material universe can be proved to be finite, we certainly cannot prove that any particular body occupies its centre. Dr. Wallace's argument is, first, that the telescopes of greatest size have failed to reveal to us fainter stars in anything like the same proportion which smaller telescopes had done; as if we were looking right through the stellar universe, and out into the blackness of space beyond. This is partly accounted for by the fact that the increase in aperture of a refractor is necessarily accompanied by an increase in the absorption of its object-glass, and we are approaching the limit where the gain and loss will be balanced. So too with the photographic plate. For medium luminosities it is perfectly true that an increase of exposure will compensate for inferiority of light in a strictly commensurable degree; but the correspondence ceases to hold good when we are dealing with very faint lights.

Dr. Wallace's next argument is an extraordinary one. He tells us, and quotes Prof. Newcomb* in his support, that were the stars infinite in number, then we should receive an infinite amount of light from them. A reference to what Prof. Newcomb actually has written shows that Dr. Wallace has omitted two important limitations which Prof. Newcomb attaches to this conclusion. It rests upon the hypotheses "that light is never lost in its passage to any distance however great," and "that every region of space of some great but finite extent is, on the average, occupied by at least one star." In short, Prof. Newcomb's demonstration rests on the two conditions that light must come through space to us without any loss, and that the stellar universe must, on the whole, be uniform in constitution; it must not be structured. We know that neither of these conditions holds good. As there are bright bodies in space, so are there dark bodies. If the first be infinite in number, so must also be the second; we may almost say that the infinity of the second must be of a higher order. As Sir Robert Ball recently put it, "the dark stars are incomparably more numerous than those that we can see . . . and to attempt to number the stars of the universe by those whose transitory brightness we can perceive would be like estimating the number of horseshoes in England by those which are red hot." The same line of argument which would infer that from an infinity of bright suns the background of the sky should shine as the sun at noonday, will lead yet more forcibly to the conclusion, when the dark stars are the basis of the argument, that we are shut in by a veil which no light from an infinite distance can pierce. On the second point, that of structure, we need only the evidence of our eyes. The existence of the Milky Way is proof that our stellar system has a strongly marked form. There is no approach to uniformity of the stars as to direction, why should we assume that there is in distance? But Dr. Wallace does not see that these two conditions are vital. He writes: "Even if we make an ample allowance for the stoppage of light by intervening dark bodies, or by cosmic dust, or by imperfect transparency of the ether, we should at least receive quite as much light from them as the sun gives us at noonday," forgetful that the entire argument depends upon the exclusion of these three causes of absorption.

The attempted demonstration of the finite nature of the universe thus breaks down entirely; it is based upon a careless reading of Prof. Newcomb's book. In his next point Dr. Wallace again rests upon Prof. Newcomb, whilst again ignoring his deductions. He quotes:—"If we should blot out from the sky all the stars having no proper motion large enough to be detected we should find remaining stars of all magnitudes, but they would be scattered almost uniformly over the sky, and show no tendency towards the Milky Way." Prof. Newcomb's words are actually somewhat different. He writes, "show little or no tendency to crowd towards the Galaxy, unless, perhaps, in the region near 19 hrs. of R.A. From this, again, it follows that the stars belonging to the Galaxy lie farther away than those whose proper motions can be detected." This conclusion of Prof. Newcomb's cannot be disputed, but Dr Wallace substitutes for it another, viz.: that stars with measured proper motions constitute a globular mass, and that we must be situated very near indeed to the centre of this solar cluster.

The points upon which Dr. Wallace lays stress as to the Galaxy, namely, that the sun is situated in its central plane, and nearly centrally with regard to it, are indeed

* "The Stars: A Study of the Universe." By Prof. Simon Newcomb.

matters of fact. But, on the one hand, so far from his having led the way in pointing out these facts, they have been fully considered by every astronomer who has treated of the Galaxy at all; and, on the other hand, he gives to the two facts a greater precision than he is warranted in doing. The Galaxy marks out roughly a great circle in the sky; it is far too irregular an object for anyone to be able to declare that its axis lies precisely along a great circle. But it is exceedingly convenient to treat it as if it did, and no error can arise from such a convention except when an argument like Dr. Wallace's is seriously based upon it. But with regard to our sun being placed in its centre, the estimate of the distance from us of the mean mass of the Milky Way is roughly three hundred light-years; a "light-year" being the distance which it takes light a year to traverse, nearly six millions of millions of miles. Our distance from Alpha Centauri is a little over four light-years, so that we have no right to say that we are nearer the centre than this twin sun of ours; nor indeed would it be safe to assert it of any of the stars whose parallax can be considered really well-determined. From the nature of the case, a distance of over thirty light-years involves a parallax too small for really satisfactory handling, and yet makes but an inconsiderable fraction of the diameter of the ring of the Milky Way.

More than that, our sun is itself travelling at a pace sufficient to bridge the distance to Alpha Centauri in sixty-five thousand years, a mere moment in our world's complete life-history. If this pace has been maintained in a straight line, five million years ago we were deep in the actual stream of the Milky Way; five million years hence we shall have completely crossed the gulf which it encircles, and again be a member of one of its constituent groups, but on the opposite side. And ten million years are regarded by geologists and biologists as but "a trifle on account" to meet their demands upon the bank of Time.

The paragraphs on "The Earth as Adapted for Life" are rather for biologists to criticise than for astronomers, but the conclusion of the paper contains several statements which almost lead us to doubt whether we have not been mistaken in supposing the article to be a serious one, and whether it was not intended as an elaborate skit on astronomical cosmogonies. How else can we regard the statement that "we can actually *see* beyond the outer boundaries" of the material universe, "a limited universe of matter and ether." To see beyond the luminiferous ether reminds one of the inventor who discovered a universal solvent, but did not know of what to make the bottle in which to hold it, so that the precious liquid was all lost. Dr. Wallace compares the stars of the Milky Way to the molecules of a gas, and suggests that "a certain proportion of them would continually escape from the attractive power of their neighbours, and wandering into outer space soon become dead and cold and lost for ever to the universe." The process, he not obscurely intimates, will be continued indefinitely, until this earth of ours, from being the centre of the universe, will become the centre of a space from which the universe has all departed. He thus offers to our poor planet only the cold comfort which Polyphemus tendered to Odysseus, that he should be eaten last. Dr. Wallace further intimates that "at any considerable distance beyond the central portion of the universe gravitation would vary in intensity in different directions," and gravely suggests that this variation may possibly be detected by means of the motions of remote binary stars.

To sum up, the little in Dr. Wallace's paper which can fairly be said to be demonstrated fact is anything but new, and that which is new, whether true or not, is as yet but speculation. His conclusions are, at the best, premature, and lie in a region which, from its very nature, must probably always be outside the bounds of our knowledge. The Milky Way, which forms the chief portion of the structure of that sidereal system in which we are placed, no doubt is finite in extent, and we can make certain statements with regard to it. But we are not yet in a position to say that all of the objects revealed to us by the telescope are included in that system; nor can we legitimately assert that what is apparently true of such of it as we can see is absolutely true of the entire material universe. Dr. Wallace's underlying error is, indeed, that he has reasoned from the area which we can embrace with our limited perceptions to the Infinite beyond our mental or intellectual grasp. We are on the earth, and can only reason, only guess, from our earthly experience of the laws, of the materials, of the conditions elsewhere. Our eyes have limited powers of vision, our mental grasp is confined, our days are but few on the earth, and our experience small; all these boundaries limit for us the universe, however vast it may actually be, and inevitably tend to make our view-point seem to be the centre of our horizon.

Letters.

[The Editors do not hold themselves responsible for the opinions or statements of correspondents.]

THE VISIBILITY OF THE CRESCENT OF VENUS.

TO THE EDITORS OF KNOWLEDGE.

Sirs,—With regard to this discussion, perhaps I may be allowed to quote from Sayce, in "Fresh Light from Ancient Monuments," 4th edition, page 120, where he says that "Ahaz had introduced into Judah the study of astronomy, for which the Babylonians were renowned, and had set up a gnomon or sundial in the palace court (2 Kings, xx. 11). It is possible that some of the astronomical literature of Babylonia, which has been recovered from the cuneiform tablets now in the British Museum, was introduced at the same time, with its multitudinous observations and predictions of eclipses, its notices of the appearance of comets, of the movements of the planets and fixed stars, *of the phases of Venus*, and even of spots on the sun. It is also possible that the Assyrian calendar and the Assyrian names of the months now first became familiar to the Jews."

I have also seen it stated that Layard found at Nineveh a rock crystal lens, which, however, in Dr. Brewster's opinion, could only have served as a burning glass.

4, East Broughton Place, Edinburgh. W. T. Mackie.

19th February, 1903.

[The oldest Babylonian *calculations* of the moon and the planets are to my knowledge the Inscriptions of the eighth year of Cambyses, which I had published in the "Babylonian Inscriptions of Cambyses," cp. "Un annuaire astronomique Babylonien traduit en partie en Grec par Ptolémée," par M. J. Oppert, "Journal Asiatique," 1890. That system of calculation had been variously improved by different astronomical schools during the reign of the Achaemenian Persian kings, the Seleucides and the Arsacides, down to the first century B.C. These calculations are mainly cyclical:—The Saros period for the Moon; for Jupiter a period of 83 years, or of 83 ± 12 years; for Venus a period of eight years; for Mercury a period of 46 years; for Saturn 59 years, and for Mars a period of 32 or 47 years,

and of 47 ± 15, and of 47 + 32 years. The greater number of inscriptions refer to observations made in order to verify and correct these periods. There are older observations of the moon known from Assyria, but chiefly made for the purpose of astrology and festival arrangements. Up to date there is no inscription known to me where the "phases of Venus" would be given; the observations are about Venus as the evening or morning star. In a later period there were elaborate systems of calculating the heliacal rising and setting of Venus and Mercury and the other planets, and the author quoted by Mr. Mackie probably meant these heliacal risings and settings of Venus by the expression "phases of Venus." Spots on the sun are never mentioned in any inscriptions, unless the author translates the word "cloud" by "spot," or has misunderstood the expression for an eclipse. The crystal lens, found at Nineveh by Sir Austen H. Layard, now preserved in the British Museum, is very roughly made, and could, evidently, not be used for any observation. The names of the Jewish months seem rather to be derived from an earlier intercourse with Babylon than from Assyria, and after the Babylonian Exile the Babylonian names were in common use amongst the Jews.—J. N. Strassmaier, s.j.]

THE CROSS OF S. SOPHIA.

TO THE EDITORS OF KNOWLEDGE.

Sirs,—In the first of M. Antoniadi's interesting papers on S. Sophia (Knowledge, for February, 1903, p. 30), he comes to the conclusion that a large cross stood outside the dome, similar to that on S. Paul's in London; but he brings no evidence in support of his contention except the passage which he quotes from Paulus Silentiarius, a passage which has been differently interpreted by very competent persons. I should like to ask if M. Antoniadi can quote any other instance in Greek literature where ἔγραφε is used for anything except a design on the flat, whether by writing or painting, or possibly mosaic. The use of ἔγραφε was certainly not caused by poetical necessities, as ἔπλασε or ἔκτισε fits the hexameter equally well. But the interpretation of the Silentiary's poem does not depend here upon the single word; the whole context of the passage refers to the magnificent appearance of the dome *from the inside*. The poet compares the dome to the vault of heaven, an idea that would never occur to anyone who was thinking of the appearance of the outside. In the age of Justinian the heavens were thought of as a great spherical vault seen from below, and the top, the κορυφή, is the zenith. At the zenith of Justinian's dome, on the inside therefore, above every object in sight, above the highest point of the enclosed space, the great cross was drawn, brooding over the worshippers.

As to the cross being the "protector of the city," surely the Byzantines were not so foolish as to suppose that the position of the cross made any difference to its supernatural virtue; and if any particular cross was to be regarded as the palladium of Constantinople, it would be not Justinian's architectural ornaments, but the True Cross which was kept inside the church and exposed there three days in the year for the veneration of the faithful. But, doubtless, ἐρυσίπτολις merely expresses the general belief that the symbol of the Christian religion everywhere protected the city of Constantine.

My regretted friend Harold Swainson is not alive to defend his translation of the Silentiary's poem. I have therefore written these few lines to express the opinion that if M. Antoniadi is to convince us that Justinian's Church of S. Sophia had a cross on the outside of the dome he will need to bring forward some other evidence than the passage he has quoted from Paulus.

Elterholm, Cambridge. F. C. Burkitt.

[In wishing to deprive mediæval Greek churches of their outer cross, Mr. Burkitt is assuming a gravely artificial position, whose defence is very difficult, if not altogether impossible The "other evidence" he is asking for is now brought forth in my third paper, printed in the present number of Knowledge, where I show that, in opposition to Mr. Burkitt's assertion that the great cross was drawn inside, "brooding over the worshippers," the poet Paulus describes at the very place of this would-be cross, the image of Christ in a mosaic circle. And we know that to paint Christ at the crown of the cupola, inside, was a recommendation of the Greek "Painter's Manual." We thus reach the irrefutable general inference: As there was a cross somewhere about the dome of St. Sophia, and as it was not inside, it must necessarily have been on the outside.

This focusses matters, and justifies the sense of *figured*, which I gave to ἔγραφε. The attempt to confine the meaning of that verb to writing and painting suggests some lack of knowledge of Greek, as, in the first place, γράφειν meant *to scratch, to incise, to carve*, all of which meanings imply, of course, action in a solid. And, in choosing the word ἔγραφε, the poet probably wanted to say that the cross was "artfully carved out" of metal. The fact that the context interesting us describes the interior of the dome is utilized by Mr. Burkitt as a corroboration of his views. But a closer examination ought to show him that it really militates against them, for, approaching as he does, the crown of the dome on the inside, the poet thought he ought to say a word on the outer cross, and actually does this by selecting the proper adverb, ὑπέρ, *above, beyond*, implying the change of plane from inside to outside.

Mr. Burkitt, further, does not see that, in placing his mosaic cross "above the highest point of the enclosed space," he locates it either in the thickness of the brick vaulting, or even draws it on the outside—both of which conclusions are, of course, unlikely.

Mr. Burkitt's letter is the product of an error in his authority's translation. The poet places his cross ὑπὲρ δὲ ἀκροτάτης κορυφῆς, literally, "but above the most extreme summit," whereas the late Mr. Swainson inadvertently translated "and at the highest point," giving to the expression ὑπὲρ δέ, *but above*, the meaning *and at*, which, I am afraid, it never had.

1903, March 12. E. M. Antoniadi.]

British Ornithological Notes.

Conducted by Harry F. Witherby, f.z.s., m.b.o.u.

The Migrations of the Lapwing.—The following is a brief summary of Mr. W. Eagle Clarke's account of the migratory movements of the Lapwing:—

Generally it may be said that the movements of this bird largely escape notice. Lapwings do not often approach the light-stations. They do not seem to emigrate from the British Islands in autumn to any extent, but they come to winter with us from the Continent. The most marked movements of the Lapwing are connected with the weather, and are mainly confined to passages from the north of Great Britain southwards, and from inland to the coast in winter, and *vice versa* in spring.

British Summer and Autumn Movements.—Commencing exceptionally in July, but generally in August, emigration from the north of Scotland and the high breeding grounds goes on gradually until the beginning of November, when the birds are mostly to be found in

the south of England, or in sheltered lowlands near the coast. During October and November too there is a passage of Lapwings from Northern Britain to Ireland.

Autumn Immigration from North-Western Europe.—Arrivals of Lapwings from Scandinavia occur throughout October and the early part of November, but in no great numbers.

Autumn Immigration from the East.—The records, although meagre, are sufficient to leave little doubt that immigrants from the Continent—occasionally in considerable numbers—arrive on our east coast by a direct passage across the southern waters of the North Sea. This immigration is renewed during severe winters on the Continent.

Autumn Passage of Immigrants.—Lapwings, it seems, do not use our coasts—as so many other birds do—as a mere highway on their passage north and south to other countries.

Autumn Emigration from Britain. — Our native Lapwings and the autumnal visitors from the Continent seem loth to quit our shores. No Lapwings have been detected crossing the Channel before November, when the approach of winter constrains some of them to seek more genial climes.

Winter Movements and Emigration. These are controlled by, and vary with, the climatic conditions of the season, and their extent is proportional to its severity. Heavy snow and severe frost cause great movements southwards along the coast and overland. Should such conditions extend to the South of England, much emigration is embarked upon for the shores of France. Devon, Cornwall, and the Scilly Isles, as well as Ireland, are also much resorted to during severe frosts and snowstorms. It is when thus retreating before adverse conditions that the movements of the Lapwing become pronounced and widespread, and, in this respect, contrast markedly with the other migrations of this species. On these occasions, too, the bird chiefly approaches the light-stations. Comparatively few perish by starvation.

Spring Movements from British Winter to Summer Haunts.—Occasionally earlier, but usually towards the end of February and early in March, the Lapwings gradually return to their breeding haunts in Britain.

Spring Immigration from Southern Europe. — The Lapwings that have left England for the south appear to return across the Channel towards the end of March.

Spring Passage Northward and Emigration to Northern Europe.—During March and until mid-April the return migration northward of the Lapwings proceeds in a somewhat leisurely fashion. The emigrants for North-west Europe mainly move along the east coast. Those that have wintered in Ireland generally depart from the north-east coast and proceed in various directions towards Scotland. No return passage in spring of Lapwings across the south of the North Sea to Central Europe has been noticed, but as these birds move by night, and are seldom attracted by the lights, there is great difficulty in observing small movements.

The Status of the Goldfinch in Britain (Zoologist, January, 1903, pp. 23-26).—Mr. J. A. Harvie-Brown here gives brief extracts from various authors to show the status of the Goldfinch in many counties. It is proposed to bring the information up to date, and to complete it as far as possible with the co-operation of different observers.

Bulwer's Petrel in Sussex.—At the February meeting of the British Ornithologists' Club, Mr. J. L. Bonhote recorded that a specimen of this bird was picked up dead near Beachy Head, on February 3rd last. Bulwer's Petrel breeds in the Canaries and Madeiras, as well as in some islands in the Pacific. It has been known to occur only once before in Great Britain, viz., in Yorkshire in 1837.

All contributions to the column, either in the way of notes or photographs, should be forwarded to HARRY F. WITHERBY, *at the Office of* KNOWLEDGE, 326, *High Holborn, London.*

Notes.

ASTRONOMICAL.—A variable star, with a period shorter than that of any variable previously known, has been lately discovered in the course of the photometric work at Potsdam. The period is 4h. 0m. 13s., and the range of variation from mag. 7·9 to 8·6. Changes of magnitude go on continuously throughout the period, so that the variability is not of the simple Algol type. The star is B.D. + 56° No. 1400, R.A. 9h. 36m. 44s., Decl. + 56° 24'·6.

In a discussion of his photographs of the spectrum of the chromosphere taken during the eclipse of 1900, Mr. Evershed confirms the conclusion, arrived at previously by Sir Norman Lockyer, that the lines of a metal which are exceptionally strong are in most cases lines which are enhanced in the spark spectrum. In explanation of the predominances of these lines throughout the whole depth of the chromosphere, and their relative absence from the Fraunhofer spectrum, it is suggested that the entire chromosphere consists of small eruptions of the nature of metallic prominences or jets of highly-heated gases, the ascending hot gases giving the predominant features to the flash spectrum, while the Fraunhofer spectrum represents the absorption of the cooler descending gases only.

Dr. Chree, of the National Physical Laboratory, finds that the equinoxes are the seasons at which the amplitude of the diurnal inequality of terrestrial magnetism, when considered absolutely, is most dependent upon sunspot frequency; and that winter is the season when sunspot frequency is most influential relatively to the total range.

Sir Norman and Dr. Lockyer find from a discussion of prominence observations that the variations of the general terrestrial magnetic phenomena synchronise with the occurrence of prominences about the solar equator (the periodicity of which appears to agree very closely with that of the spots), while the "great" magnetic disturbances accompany the outburst of prominences in the polar regions of the sun. This may explain why magnetic storms sometimes occur when no large spot is visible.—A.F.

BOTANICAL.—One of the most remarkable among amphicarpous plants is *Cardamine chenopodifolia*, which has recently been the subject of a paper by Dr. E. P. Wright in *Notes from the Botanical School of Trinity College, Dublin.* This interesting Crucifer is a native of various parts of South America, from Brazil to Argentina and the Island of Juan Fernandez. It produces an aerial raceme of small flowers, which are succeeded by seed-pods similar to those of the British *C. impatiens.* They are usually many-seeded and dehisce elastically, scattering the seeds to some distance. But in addition to the aerial flowers and fruits, others are produced at the base of the plant. The flowers are cleistogamous, extremely minute, without petals, and are borne separately at the tip of subterranean peduncles. The fruit is short and thick, two-celled, and contains one large seed in each cell. This is probably the only amphicarpous Crucifer, but at least two other plants of the order are known which mature their fruit underground, namely, *Morisia hypogæa*, a native of Corsica and Sardinia, and *Geococcus pusillus*, a miniature plant from Western Australia. The former grows in the Rock Garden at Kew. The fruits in both these develop much in the same way as those of the Earth-nut, *Arachis hypogæa.* Amphicarpous plants are found in various natural orders, some particularly interesting ones being discussed in a paper by Dr. Lindman in the *Öfversigt K. Vet.-Akad. Förhandl.*, Stockholm, for 1900.

Sir J. D. Hooker's biography of his father, Sir W. J. Hooker, appeared in the December number of the *Annals of Botany*, and is worth perusal by the general reader as

well as by those specially interested in botanical science. The history of this remarkable man intimately concerns the Royal Botanic Gardens, Kew, of which he was director from 1841 to 1865, previously having been Professor of Botany in the University of Glasgow. The extinction of Kew as a botanical establishment was seriously considered at the close of Mr. Aiton's term of office, but narrowly escaping such a fate, the gardens soon rose, through Sir William Hooker's directing energy, to the foremost position among the botanical institutions of the world. The author of many splendid works, his connection with the *Botanical Magazine* is particularly interesting. This famous serial came into existence in 1787, two years after the birth of Sir William Hooker, was continued throughout his long life, which terminated in 1865, bearing for years on its title-pages his name as editor, and in many cases the plates with his name as artist, and is existing still, controlled by another Hooker, the author of this entertaining biography.—S. A. S.

Entomological.—Conspicuous in Prof. J. W. Gregory's book on the "Great Rift Valley," is a coloured frontispiece representing the protective resemblance of certain homopterous insects to a flower-spike. The insects are shown grouped on an upright stem, small green individuals above representing unopened buds, and larger red specimens below looking like blossoms. In a recent paper in the *Trans. Entom. Society* (1903, pp. 695-698, pls. 26-27), Mr. S. L. Hinde, who has studied the habits of these insects in East Africa, states that the green individuals are as large as the red, that he has never observed them on vertical shoots, but always on horizontal branches, and that the red and green forms occur mixed together. Nevertheless, the whole effect is strikingly like the inflorescence of a leguminous plant common in the district. The larvæ, which are protected by long white waxy threads, do occur in companies on vertical shoots, and present a remarkable appearance. The insect has been identified as *Flata nigrocincta*, Walker.—G. H. C.

Zoological.—In the *Annals and Magazine of Natural History* for December, Mr. O. Thomas describes a new mole (*Talpa romana*) from the neighbourhood of Rome. This species differs from both the common mole and the South European Savi's mole (*T. cæca*) by the much larger teeth, as well as by certain peculiarities in the skull. Savi's mole, it may be remarked, differs from the common species in having a membrane of the eyes, and being therefore truly blind. It is decidedly remarkable that such a distinct form should so long have escaped the notice of naturalists. A wood-mouse collected by Mr. H. F. Witherby, at an elevation of over 5000 feet, near Sheoul, in the Fars district of Persia, has been described by Mr. Thomas in the same issue as a new race, under the name of *Mus sylvaticus witherbyi*. It is characterized by the pure white under-surface, and the small size of the teeth.

The full text of Dr. W. G. Ridewood's valuable memoir on the structure of the gills of the lamellibranch molluscs, the abstract of which was noticed in these columns when it appeared in the *Proceedings* of the Royal Society, has recently been issued in the *Philosophical Transactions*.

Much difference of opinion obtains as to the mode in which the more complicated cheek-teeth have been evolved from teeth of a simpler type. By some authorities it is considered probable that the primitive type was a tooth with three cusps on the crown arranged in the form of a triangle (tritubercular type). Others, on the contrary, favour the idea that complex teeth have been developed by the fusion of two or more teeth of a simple conical type. This view, with certain limitations, receives support in an illustrated article by Dr. H. W. M. Tims, published in the January number of the *Journal of Anatomy and Physiology*.

Many persons have probably been puzzled to account for the circumstance that while the ancestral wild cavies are uniformly greyish coloured animals, the domesticated guinea-pig is usually marked with patches of black, orange, and white. The explanation is, however, not far to seek. As the result of hybridisation, what is known as the dissociation of colours frequently takes place. For instance, hybrid mice may be either black or sandy coloured. The black breed is due to the elimination (probably by crossing with an albino) of the rufous element in the colouring of the typical grey coat; while, conversely, sandy or fawn-coloured mice are the result of the elimination of the black constituent of the compound colour. The various distinct colours, or patches of colour, in the guinea-pig have doubtless originated in a similar manner; that is to say, by the breaking-up of the composite colour of the coat of the wild guinea-pig owing to a cross with an albino subject. Those desirous of further information on this subject, and likewise on the fact that hybrids produce offspring of which some resemble one of their grandparents and some the other, should consult an article on Mendel's law of heredity, recently published by the American Academy of Arts and Sciences.

According to the view of Dr. Scharff, as expressed in a paper recently published in the Royal Irish Academy's *Proceedings*, the "Atlantis" of Plato was a reality and not a myth; Madeira and the Azores having been connected by land with the European and African continents so late as the early portion of the human period. This connection was, however, but the last phase of a great Atlantic continent, which the author believes at an earlier epoch to have extended from Morocco (which was then connected with Portugal) to South America, reaching at least as far south as St Helena. The evidence in favour of this former extensive land connection has been drawn from a careful survey of the whole fauna of the Atlantic islands, which displays marked affinities with that of the Mediterranean countries on the one hand and that of South America on the other. That a land connection between Africa and South America existed at a relatively remote geological epoch is now generally admitted; but stronger evidence will, we think, be required before the theory that the Azores were in connection with Portugal during the human period is accepted. One of the author's arguments is based on the circumstance that so far back as 1385 two of these islands were named from their being inhabited respectively by rabbits and goats, at a time when there were no human denizens of the group. Hence, it is urged, these animals were indigenous, and not, as generally supposed, introduced.

Naturalists will read with interest a paper by Mr. E. T. Newton, in the last number of the Geological Society's *Journal*, describing remains of the elk recently discovered in the Thames valley. The author alludes in some detail to previous finds of elk-remains in this country.

The total result of last year's whaling and sealing by British vessels, according to Mr. Southwell's annual report in the *Zoologist*, was 12 right whales, 652 white whales, 118 walrus, 1984 seals, and 168 bears. Apart from hides, these yielded 212 tuns of oil, worth £22 10s. per tun, and 187 cwt. of whalebone, which now sells at £2500 per ton. Some years ago the price of whalebone reached £2800 per ton; the reduction is probably due to the use of strips of horn for many purposes where whalebone was formerly employed, since the supply of the latter article has certainly not increased.

The ideas generally held with regard to some of the habits of the common mole have been to a considerable extent revolutionized by observations made by Mr. L. E. Adams in Staffordshire, the results of which appear in a recent issue of the *Memoirs* of the Manchester Literary and Philosophical Society. The author shows that the tunnels in the "fortress" or nest-hillock are in nowise constructed on a definite plan with a view to the escape of their owner when danger threatens. He even finds that there is an error with regard to such a simple matter as the number of teats possessed by the female mole. The moral of all this is that we must take nothing on trust in zoological matters.

Zoologists, geologists, and geographers should alike find much to interest them in an essay by Mr. F. W. Harmer on the history of the changes which have taken place in East Anglia during the latter part of the Tertiary period. The essay will be found in the *Proceedings* of the Geologists' Association for 1902.

Some very pertinent remarks on the subject of labels in museums are made by Mr. F. A. Bather in the *Museums' Journal*. After mentioning the advisability of putting popular names on the labels of a large number of specimens, and certain difficulties connected with determining what names to select, the author alludes to the practice which obtains in some museums of adding an abbreviation of the name of the writer responsible for the scientific species-name. If authors' names are given at all, they should be given, Mr. Bather urges, at full length, as otherwise they are absolutely unintelligible to the general public. But are they necessary at all?—he asks; we think not. It may be added that the conventional signs for male and female appended to the names of animals in the Zoological Gardens, Regent's Park, afford another example of the use of abbreviations unintelligible to the public.

Notices of Books.

"In the Andamans and Nicobars: the Narrative of a Cruise in the Schooner 'Terrapin,' with Notices of the Islands, their Fauna, Ethnology, etc." By C. B. Kloss. (John Murray.) Pp. xvi. + 373. Illustrated. Price 21s. net.—Mr. Kloss had the good fortune to accompany the energetic and successful American collector, Dr. W. L. Abbott, in a cruise to the Andamans and Nicobars, undertaken for the purpose of obtaining specimens of their mammals and birds. And it must be acknowledged that, by the production of the volume before us, he has taken full advantage of the opportunities thus afforded him of adding considerably to our information with regard to these interesting islands and their inhabitants. In the case of the Andamans, the author confesses indeed that Mr. Marr's well-known volume on the aborigines has left comparatively little for other observers to record with regard to the anthropology and ethnology of these islands. But in the Nicobars the state of affairs is very different, and Mr. Kloss urges that much ethnological work still remains to be done, and that the time is short during which it will be possible to do this effectively, since the natives are daily changing their primitive customs and habits. A valuable feature of the work before us is to be found in the numerous portraits of Andamanese and Nicobarese with which it is illustrated. Mr. Kloss divides his work into two parts, namely, a narrative of the cruise, and a dissertation on the human and other inhabitants of the islands. These two groups of islands present the peculiarity that whereas the Andamans are inhabited by a negro-like (negrito) race, which is perhaps one of the most primitive types now left on the earth, the Nicobars are populated by tribes belonging to the great Malay stock. The most primitive of the natives of the Nicobars are undoubtedly the Shom-Pen of the interior of Great Nicobar, who appear to be remnants of the aborigines more or less crossed with foreign (perhaps Dravidian) blood. The coast natives of Great Nicobar, as well as the inhabitants of the other islands, are, on the other hand, a later importation, and appear to have originated from a mixture of the aborigines with Malays and Chinese. Mr. Kloss lays great stress on the difference between the Andaman-Nicobar mammals and those of the mainland, commenting on the great preponderance of bats and rodents. This difference, he thinks, indicates that these islands were detached from the mainland before the latter received its present fauna; and he is further of opinion that the Andamanese and Shom-Pen may themselves have introduced some of the mammals, whose differences from their relatives of the mainland may have developed within the period of human occupation. The volume is of the highest interest, both as a record of a delightful trip, and as a mine of information to the zoologist, the anthropologist, and the ethnologist.

"Mont Pelée and the Tragedy of Martinique." By Angelo Heilprin. (Lippincott.) 15s. net. Illustrated.—Professor Heilprin was one of the earliest and most fearless investigators of Mont Pelée after the eruption of last May 8th. He arrived in Martinique on May 25th, ascended the mountain for the first time six days later, and during a second visit to the island was a spectator, and nearly a victim, of the eruption of August 30th. The work that he has produced is splendidly illustrated by reproductions of numerous photographs, and written in a style which, if it occasionally approaches that of a newspaper correspondent, is always clear and interesting. We find in it graphic accounts of a great event, of the days of preparation and neglected warnings, and of the resulting devastation of the country; and these should be sufficient to secure for the book a wide approval. The author is convinced that the principal agent in the tornadic blast of August 30th, and probably also in those of May 8th, etc., was "superheated exploded steam, charged in part with particles of incandescent or glowing matter"; and, in a suggestive chapter on Vesuvius and Pompeii, he argues with considerable force that the destruction of the latter city may have been caused by a similar explosive blast. The whole subject of the West Indian eruptions is a very wide one, in reality beyond the scope of a single investigator, and it is not therefore surprising that Prof. Heilprin should be occasionally inaccurate. For instance, some tremors recorded at Zi-ka-Wei in China are referred by him to vibrations "propagated clean through the centre of the earth," although no records of them were obtained in Great Britain, and the time interval of nearly 4½ hours was more than sufficient for even the long-period undulations to travel completely round the globe. But, notwithstanding a doubtful statement here and there and a tendency to sensational writing (*e.g.*, "the unfortunate French island, now writhing in the coils of the dragon that wrought its earlier fabric"), Professor Heilprin has written a book that can hardly fail to be of permanent value.

"Modern Microscopy." By M. I. Cross and Martin J. Cole. 3rd ed.; pp. xvi. and 292. Illustrated. (Baillière, Tindall & Cox.) 4s. net.—We heartily welcome the third edition of this now well-known work, which fills a position of its own in modern microscopical literature, and which should be in the possession of every worker with the microscope. Though modest in its apparent scope, it contains within its covers an exceptional amount of most valuable information, whilst the general arrangement and the directness and lucidity of the explanations merit the highest praise. The beginner, and he even who is not a beginner, will learn more from these pages than from more pretentious and costly volumes, he will find it an absolutely trustworthy guide to the choice of his instrument, wherein lie so many doubts and difficulties, and a careful perusal of its pages will give him an insight into and a command over the workings of the microscope which will be of the utmost value to him, whether as an amateur or as a serious student. The book is divided into three divisions. In the first, Mr. Cross takes the various parts of the microscope in their natural order; first the stand, its types, its coarse and fine adjustments, and their respective merits, the stage and sub-stage, and the refinement which modern critical work has called forth. Then follows a chapter on optical construction, which is nothing if not practical, and in which the theoretical side is confined to a series of definitions, some of which might possibly be extended with advantage. Illumination and illuminating apparatus are next dealt with, and we observe with strong approbation not only the stress laid upon the necessity for using a condenser, but the equal necessity that the corrections of the condenser should approximate in perfection to those of

the objectives. For advance in this respect, Mr. Cross rightly gives the credit to the leading English manufacturers, who have throughout seen the futility of producing an objective the corrections of which make it one of the most perfect of optical productions, and allowing it to be used in a way that practically nullifies the very excellencies for which so much is claimed. In the remaining chapter of this part accessories are dealt with in an equally satisfactory manner. In the second part Mr. Cole deals with the preparation and mounting of objects as might be anticipated in a mounter of his experience. His tables are excellent in every way, his instructions plain and unmistakable, his methods above criticism. This part of the book has a value of its own to all practical workers, and has been much extended in the present edition. Finally, a new chapter on microtomes, their choice, use, and the preparation and cutting of sections, has been contributed by Mr. G. West, of Edinburgh, which is not inferior in lucidity to the rest of the book. In the next edition we shall hope to see a further chapter on photo-micrography.

"What Star is it? Tables for Identifying Unknown Stars." By Herbert W. Harvey. (Spottiswoode.) 1s. net.—This very handy little volume is intended to assist navigators to identify stars of the second or third magnitude, the altitude of which they may have observed, and so to avoid the discarding of "sights" when the object observed is not known with certainty. It consists of a set of very neat and clearly printed tables, giving the hour angles and declinations of celestial objects for every five degrees of altitude from 10° to 65°, and for every ten degrees of azimuth. The book makes an extremely handy pocket volume, and will no doubt be very useful to many others beside navigators who wish to be able to convert right ascensions and declinations into altitudes and azimuths, or *vice versa*, where this only needs to be done approximately.

"Open-Air Studies in Geology." By Prof. Grenville A. J. Cole. Second Edition. Revised. Pp. 322. (London: Charles Griffin & Co.) Illustrated. 8s. 6d.—Professor Cole is so well and favourably known to readers of Knowledge that any writings by his pen are assured of a welcome. In a work of the kind under notice he is at his best. His style is popular without being childish, and accurate without being pedantic; the result is a volume which creates interest in the physiognomy of the Earth, and forms the best of introductions to the serious study of geology. Open-air studies are essential in the making of a geologist, and it is only after personal observation of characteristic rocks and scenes that a student is in a position to understand clearly their geological significance. Every intelligent observation is of sterling value in the store of a person's knowledge, and only those who have seen things for themselves can express an opinion upon them worth much consideration. As Prof. Cole remarks, "Almost all great progress in natural knowledge has thus been made by those who have seen and travelled—by those, in fact, who have studied in 'Nature's roofless school.'" His book should be the means of adding to the number of intelligent observers of the Earth's features. The text, the illustrations, and the numerous references will all help the student to understand and interpret the features of Mother Earth.

BOOKS RECEIVED.

Variations in Animals and Plants. By H. M. Vernon, M.A., M.D. (Kegan Paul.) 5s.

Ancient Greek Sculptors. By H. Edith Legge. (Unwin.) 6s.

Comets and their Tails and the Gegenschein Light. By Frederick G. Shaw, F.G.S. (Baillière, Tindall & Cox.) 2s. 6d. net.

British Ferns. By Chas. T. Druery, F.L.S., V.M.H. (Newnes.) Illustrated. 3s. 6d. net.

Chemical Technology. Vol. IV. Edited by W. J. Dibdin, F.I.C., F.C.S. *Electric Lighting*, by A. G. Cooke, M.A., A.M.I.E.E.; *Photometry*, by W. J. Dibdin, F.I.C., F.C.S. (Churchill.) Illustrated. 20s.

Triumphs of Science. Edited by M. A. Lane. (Ginn & Co.) 1s 6d.

David and Bathshua. By Charles Whitworth Wynne. (Kegan Paul.) 5s.

How to become a Private Secretary. By Arthur Sheppard (Unwin.) 1s.

The Burlington Magazine. March, 1903. (Savile Publishing Co., Ld.) 2s. 6d. net.

The Rationale of Telepathy and Mind Cure. By C. W. Leadbeater. (Theosophical Publishing Society.) 6d.

Proper Motions of the Stars. By Gavin J. Burns. (University of Chicago Press.)

The Extension of the Foreign Trade Relations of the United States. (Philadelphia: Commercial Museum.)

Memorias y Revista de la Sociedad Cientifica "Antonio Alzate." (Mexico: Avenida Oriente 2. núm. 726.)

Report of the Advisory Board of the Commercial Museum, October 7, 8 and 9, 1902. (Philadelphia.)

Journal of the Society of Comparative Legislation. December, 1902. (Murray) 5s.

Transactions of the City of London Entomological and Natural History Society, 1902. 2s.

Quarterly Record of Additions. No. III. By Thomas Sheppard, F.G.S. (Hull Museum.) 1d.

Short Manual of Inorganic Chemistry. By A. Dupré, PH.D., F.R.S., and H. Wilson Hake, PH.D., F.I.C., F.C.S. (Chas Griffin & Co.) 6s. net.

Papers on Mechanical and Physical Subjects. Vol. III.—*The Sub-Mechanics of the Universe.* By Osborne Reynolds, M.A., F.R.S., LL.D. (Clay.) 10s. 6d. net.

Experiments with Vacuum Tubes. By Sir David L. Salomons, Bart., M.A. (Whittaker.) Illustrated. 2s.

Report of S. P. Langley, Secretary of the Smithsonian Institution, for the Year ending June 30, 1902. (Washington: Government Printing Office.)

Raines & Co., Ealing.—Photographic Catalogue.

1903 Catalogue, Thornton-Pickard Manufacturing Co., Ltd., Altrincham.

Catalogue of The Service Photographic Society, High Holborn, London.

ST. SOPHIA, CONSTANTINOPLE.

By E. M. Antoniadi, F.R.A.S.

Illustrated from original drawings and photographs by the Author.

III.

The Interior.

It is from the north porch that visitors are now admitted into the mosque. They enter by the door of the celebrated "Sweating Pier," which Messrs. Lethaby and Swainson have so ably identified with the column of St. Gregory the Miracle Worker, and are then led eastwards, along the north aisle, to the sanctuary; returning by the southern division of the church. It is noteworthy that this mode of receiving tourists does not seem to have been dictated merely by the requirements of the mosque; for to guide visitors round "after the sun's path" was an old Greek tradition, to which allusion is already made in 1350 by the Russian pilgrim, Stephen of Novgorod.*

We shall not, however, adopt this course in our description. Following the emperor on feast days, we will enter the church by the Horologion, on the south side, when our attention will be at once attracted by the "Beautiful Gate" of Constantine Porphyrogenitus. The eastern panel of this door bears the inscription

ΜΙΧΑΗΛΝΙΚΗΤΩΝ

or "Michael of Victors," while the opposite panel was believed by Messrs. Curtis and Aristarches to have borne the words

ΘΕΟΦΙΛΟΥΚΑΙ

which would complete the inscription into "Of Theophilus and Michael Victors." Now, the fact that the monograms of both these emperors are also given on the panels, lends great weight to this amendment. On the other hand, we know that the names of Theophilus and Michael were often wedded together on public buildings, and Byzantios, for instance, mentions† the following inscription from the

* *Société de l'Orient Latin, Séries Géogr.*, Vol. V.

† Ἡ Κωνσταντινούπολις, Vol. I., Athens, 1857, p. 104.

land walls of Constantinople: Πύργος Θεοφίλου καὶ Μιχαὴλ πιστῶν ἐν Χριστῷ Αὐτοκρατόρων, or "Tower of Theophilus and Michael, emperors faithful to Christ."

As amended by Messrs. Curtis and Aristarches, the inscription remains, however, in the plural genitive. Such sentences are hardly sensible in English; but in Greek they are known as forms of the possessive genitive, with elimination of the associated substantive. That such elimination was actually resorted to before the words ΘΕΟΦΙΛΟΥΚΑΙ, is anything but certain. It will be seen, on the contrary—

(*a*) That the words added by the authors in question fill a much smaller space than the remaining part of the inscription, especially if the conjunction ΚΑΙ, "and," was, as usual, abbreviated into a mere K; and

(*b*) That in the inscription of the same emperors, quoted from Byzantios, the plural possessive case is preceded by an all-important nominative, πύργος, "tower."

The writer suggests, therefore, that the missing nominative in the south porch of St. Sophia was ΠΥΛΗ, "Gate," when, instead of the elliptical genitive "Of Theophilus and Michael Victors," the inscription would run in the cartouches

ΠΥΛΗΘΕΟΦΙΛΟΥΚ ΜΙΧΑΗΛΝΙΚΗΤΩΝ

or "Entrance of the Victorious [Emperors] Theophilus and Michael." The reason of the absence of Theophilus's name from the western panel is perhaps not difficult to find out. By the synod of 842, Iconoclasm was declared to be a heresy, so that we should hardly expect the name of the last Iconoclastic emperor to have been tolerated in the very entrance of Orthodoxy.

In addition to this inscription and to the monograms, the panels bear the date 838 A.D., which may be rendered instrumental in establishing that the south porch existed already in 838, and that it was probably erected, with the four ascents to the galleries, by the emperor Theophilus, with a view to buttressing the angles of the church.

Just before one reaches the north exit of the porch, a little door, leading to a recess of the eastern wall, should be noted; for it was here that the emperor had his crown removed on entering the church in great ceremony.

The Grand Vestibule or *Narthex* of the west front now claims our attention. It is shorter than the church is broad, and there is no evidence showing that it was originally larger, so that the Silentiary's statement to the effect that it occupied the whole breadth of the building is a slip, the only one, however, which it is possible to find in that wonderfully accurate description.

At some distance over the lintel of the great central door, to the west, the writer has been shown four marble guns, which the Turks report to have belonged to the last Constantine. "They were not always of marble, but in metal; having been petrified at the fall of the City."

Like those of the south porch, the vaults of the Narthex are still glittering with mosaic, that most powerful element of decoration.* The identity of the fine image of the emperor kneeling before Christ, above the Royal Gate, is not known. Antony of Novgorod well says that "above the door is depicted, on a large panel, the emperor Leo the Wise," but whether allusion is here made to this door, or not, is uncertain. The medallion to the left represents the Virgin, the one to the right the Archangel Michael, and not "a winged Prodomos," as assumed by Grelot, Byzantios, and Canon Curtis. During a recent visit to St. Mark's, Venice, the writer was struck by a golden Greek eikon of Michael, with the inscription ΜΙΧΑΗΛ, said to come from St. Sophia, and which is practically identical to the medallion in question.

A restoration of the Narthex has been undertaken in Fig. 6. The appearance of the Vestibule does not seem to

Fig. 6.—The Grand Vestibule.

have been much altered since Byzantine times. No doubt the number of lamps hung from the vaults must have been incomparably greater than shown in the picture, and it is also strongly to be suspected that stalls used to stand here, at least along the western wall. It has been thought preferable, however, not to overcrowd the view with these accessories, so as to avoid seriously interfering with the perspective.

The central Royal Gate is a symbol of Christ, as the inscription above reads as follows:—"Our Lord hath said, I am the door of the sheep; by Me if any man enter in, he shall go in and out, and find pasture." A comparison of this passage with St. John's Gospel, ch. x., will show that we have here no exact transcript from the latter, but merely a combination of paragraphs 7 and 9, where the words "he shall be saved" are omitted.*

* In his *Facts and Comments*, Mr. Herbert Spencer complains of the mosaic lining of St. Paul's Cathedral, as mosaic is considered by him under the heading "Barbaric Art." Now everybody visiting Venice prefers the mosaic decoration of St. Mark's to the whitewash vaults of other Venetian churches, so that to depreciate mosaic decoration is an extravagance most distinctly antagonistic to the artistic ideas of mankind.

* Fig. 7 is a photograph by the writer of one of two Gospels coming from St. Sophia, and now kept in a Milner's safe at the Greek church of St. George, near Edirneh Kapu, Constantinople. The inside is a grand piece of penmanship with illuminated letters. The photograph shows the purple velvet cover, on which is fixed a noble crucifix in *repoussé* metal, as well as four discs representing the Evangelists symbolically by the beasts of the Apocalypse (*Revelation* IV., 6-7).

On entering from the Grand Gate, the first impression is one of vastness, as all the wide and aerial expanse of the vaults and the gorgeousness of the colonnades is at once embraced from the door. But it is especially from the centre of the west gallery, seat of the empress, that the view of the interior assumes all its grandeur. The amazed observer is at a loss as to what to admire most: the extreme beauty of the marble decoration; the harmony of the lines; the constantly receding surfaces of the vaulting, which carry the supporting parts to remoter backgrounds; or the subordination of all this to the crowning idea of symbolizing the heavens by the central dome, where Christ was depicted ruling the universe.

An unpretending attempt at a restoration of the view in question, giving a remote idea of the structure as first devised by Anthemius, will be found in Plate I., in the February number of Knowledge. The polygonal building shown in the foreground, to the left of that Plate, and inspired by the fine "Capitello" of St. Mark's,

Fig. 7.—Cover of a Gospel from St. Sophia.

Venice, marks the mouth of the cistern extending under the church The water in this well is reported to always stand at the same level, some two yards under the floor. There is much to confirm the suspicion of Byzantios that a priest used to stand here on Sundays, blessing the people with holy water. Meantime the images of saints whose name-day it was, ought also to have been daily exposed somewhere in this part of the nave.

Grand as the present lighting of the mosque is at night time during the Rhamazan, it can scarcely stand comparison to what it was before the Latin conquest of Constantinople. The Jewish rabbi, Benjamin of Tudela, who visited St. Sophia towards 1171, after asserting that "there is no temple in the universe possessing so many riches as this one," says: "In the middle of the church are columns of gold and silver, and candelabra of the same metals in so great numbers that it is impossible to count them."* It was in three successive circles that the polycandela hung over the nave. The majority of the lamps had the form of the discs represented by Messrs. Lethaby and Swainson,† and repeated by the writer in his restorations, while the others were shaped into huge crosses.‡ Two series of openings, pierced circlewise in the vault, mark the suspension of the inner circles, while the larger circumference, almost 100 feet wide, hung from a multitude of metal hooks, which one can still see projecting from the cornice of the dome.

We are informed by Agathias that the original design of the lateral arches was different from what is now seen. However, the obscure text of the historian had led astray many a writer, so that great credit is due to Messrs. Lethaby and Swainson for having been the first to put meaning to it, and for showing what must have been the original appearance of the north and south walls of the nave.§ The writer considers the conclusions of these two authors on this point, as well as on the primitive design of the row of niches over the central colonnades of the galleries, to constitute two very important truths added to our knowledge of the church. He thought, therefore, that the best way of doing full justice and honour to Messrs. Lethaby and Swainson was to utilize their discovery in his restoration, and to cheerfully acknowledge the fact in this description of his Plate of the interior, published in the February number of Knowledge.

Theophanes tells us that the original dome was flatter by 20 feet than the present one, and Zonaras increases this to 25. To render these data intelligible, the investigator should consider the probable requirements with which the architect must have been confronted. These seem to have been:—

(*a*) The desire of having an "aerial" dome, *i.e.*, borne on pendentives, but not constituting their continuation;

(*b*) The advantage of a cornice at its base for the lamplighter;

(*c*) The placing the centre of the dome's curvature at the height of some important architectural feature of the design; and

(*d*) The necessity of giving the total altitude of the church a round number of Byzantine feet.

A continuous pendentive cupola is most unlikely, as it would be some 29 feet flatter than the present one—a value which historical data contradict—and also for the reason that it could not satisfy (*a*) and (*b*) of the preceding requirements. Of the two historians mentioned, Theophanes is the more trustworthy. It will be seen that Zonaras makes the height of the building 155 feet; but, though his dome becomes parallel to the spherical surface generated by the pendentives, the fact that the cornice is rendered impossible is a grave objection to the veracity of his value. On the contrary, the dome of Theophanes fills all the above conditions: it rests on the pendentives, without forming their continuation; it leaves room for the lamplighter; has its centre at the level of the culminating

* *Voyage de Rabbi Benjamin, Fils de Jona de Tudele*, transl. by Baratier, Amsterdam, 1734, pp. 46–47.

† *S. Sophia*, p. 112, Fig. 16.

‡ The splendid cross under the west dome of St. Mark's, Venice, is of Greek workmanship, and, most probably, comes from St. Sophia.

§ *S. Sophia*, pp. 212–214.

point of the eastern apse; and carries the altitude to 160 feet—a round number, and a multiple of the number 40, so frequently met with in Byzantine architecture. It was evidently for the sake of the "aerial" cupola and of the cornice that the idea of a continuous pendentive dome

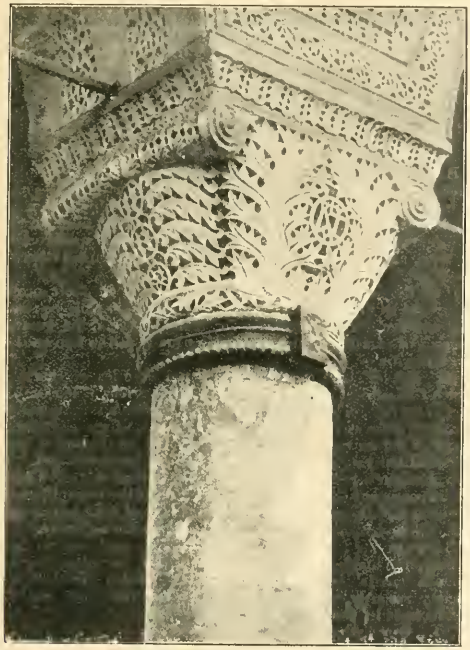


Fig. 8.—Capital of one of the Great Columns of the Nave, with the Monogram of Justinian.

was rejected. Under the existing circumstances, however, such aerialty was not to be obtained in connection with a flat dome, except at a tremendous cost of solidity. The thrust exerted by the over-daring cupola of Anthemius on the piers and semi-domes was so overwhelming that a catastrophe through failure of some point of the supports could not long be averted.

It is generally believed that Paul the Silentiary does not mention any mosaic images on the vaults in 563. Such, however, is not the writer's impression. The poet's description of the dome has not been preserved intact; there is a lacuna in the Greek text from verse 80 to verse 92, and, amid the *débris* of words, overlooked by all authors, we find :—

90. . . . . . . ἔνδοθι κύκλου
91. . ψηφίδ . . . ὄφρα σαώσῃ
92. . ειφρουρ . . κόσμοιο σαωτήρ,

that is, in English :—

"In a circle—mosaic—in order to save—always well guard {ing / ed}*—the Saviour of the World."

The *Painter's Manual* recommended to "draw near the summit of the cupola a circle of different colours. . . . In the centre represent Christ with the Gospel, and this inscription: 'Jesus Christ the Almighty.'" And it is evident that the great analogy between this description and the few remnants from the broken verses constitutes a positive proof of the important fact that the Pantocrator has adorned, from the very onset, that most genuine representation of the flattened vault of heaven.

(*To be concluded.*)

* The remnant ειφρουρ seems to be some combination of ἀεί, "always," and φρουρέω "I guard." The adjective, in poetic language, is ἀείφρουρος or ἀειφρούρητος.

MICROSCOPY

Conducted by M. I. Cross.

NOTES ON THE COLLECTION, EXAMINATION AND MOUNTING OF MOSSES AND LIVERWORTS.

By T. H. Russell.

(*Continued from page 70.*)

As far as my acquaintance with glycerine jelly goes—and it is one of a good many years' standing—the great objection to its use arises from the fact that after a specimen has been mounted in it, and has stood possibly for years, the jelly may develop an unpleasant tendency to liquefy, as will be evidenced by the presence of small beads of glycerine round the edge of the cover-glass. Moreover, this seems to come about without its being possible to track the cause of the mischief. For instance, I have slides which were put up twenty years and more ago, and which have never shown any signs of deterioration, while others, which have lain side by side with these, and which did not date back nearly so far, have had to be discarded as failures. Some time ago I had the misfortune to lose a large portion of my then small collection in the above manner, and since then have constantly been on the look-out for indications as to how such an occurrence could be avoided in the future. While not being able, so far, to suggest any unfailing remedy, I have come to the conclusion that there are, nevertheless, a few simple rules the careful observance of which will considerably minimise the risk of such a disappointing experience as that to which I have alluded. These are :—

1. Care should be taken to remove the preparatory fluid from the surface of the object, as far as possible, before mounting.
2. No pressure should be applied to the cover-glass in order to keep it in position, its own weight being alone sufficient for the purpose.
3. A sufficient quantity of the jelly should be used to allow of a small portion extending on every side beyond the edge of the cover-glass.
4. The slide should stand for at least two or three months before the additional jelly is removed and the cell sealed, as this ensures the due contraction of the jelly.
5. The slides should not be kept in a draughty position.

During the past few years I have frequently used formalin in my mounts, and up to quite lately, with what seemed to be most satisfactory results. My *modus operandi* has been as follows :—While the slide is on the hot-water bath, with a small pool of melted jelly on it, ready to receive the object, I drop into the jelly, from the end of a thin glass rod drawn to a point, a drop of 40 per cent. solution of formalin; then quickly mix this with the jelly by the help of a dissecting needle, arrange the object and place the cover-glass in position. All these latter steps have to be carried out with considerable expedition, on account of the speed with which the jelly sets when once the formalin is added. After the slide has cooled, the jelly will be found to have solidified into a firm compact mass, and whereas in an ordinary mount a moderate degree of heat would suffice to re-melt it, now even soaking in boiling water has no such effect. The binocular dissecting microscope

will be found especially useful in this process, as the lenses form a good screen for the eyes from the otherwise too pungent fumes of the formalin.

It occurred to me that possibly the formalin might injuriously affect the delicate cell structure of the moss leaves, but experiment assured me that this need not be feared, and I began to hope that here, at least, was a method of mounting that would practically eliminate all serious risk of failure. My disappointment was consequently great when, on going to my cabinet a couple of months ago, I found that several of the slides mounted with formalin had gone wrong. What puzzles me all the more is that slides in the same drawer, put up some with formalin and some in the ordinary way, show no sign of change. Thus slides of *Hypnum, Commutatum* and *Andreaa alpina* mounted five or six years ago give no indication whatever of deterioration, while others, completed fully twelve months since, and which have purposely been allowed to stand in a room without a fire, are still in a perfectly satisfactory condition. Moreover, in January, 1902, I put a few drops of the jelly on a glass slide, and mixed with them a little of the formalin solution ; this slide has also laid in a room without a fire, and the jelly, though unprotected by a cover-glass, is still compact and firm. The drawer containing the specimens in question happens to be the one nearest to the ground, and the cabinet stands in a corner of my dining-room furthest removed from the likelihood of draught, but as the door of the cabinet fits closely, it is difficult to believe that change of temperature constitutes the explanation, especially as the slides in the drawer not far above the one in question are unaffected. I have recently been making still further experiments, though sufficient time has not yet elapsed for any definite conclusions to be drawn from them ; on the whole, however, I am inclined to think that too much formalin was used in the mounts referred to, and that herein lies the cause of their failure. Of late, therefore, I have dipped little beyond the extreme point of the glass rod into the formalin solution, thus transferring a much smaller quantity to the jelly in the cell ; this will not, of course, solidify the jelly so thoroughly as if the larger quantity were used, but, on the other hand, it will not have the same contractive power.

In concluding these notes, let me again emphasise what I said at the outset, namely that they have been written in the hope that others may thereby be induced to give the results of their experiments in the matters of which they treat, a remark which specially applies to the somewhat full details given with regard to the use of formalin. I am well aware that much that they contain will certainly not be fresh to many workers, yet possibly for some who have not long taken up the study, there may be in them a few practical hints which will be of service.

THE MOUTH PARTS OF THE TSETSE FLY.

By W. Wesché, F.R.M.S.

It cannot be denied that it would be difficult, if not impossible, to find a more destructive instrument than the proboscis of the Tsetse fly (*Glossina*). Yearly it causes the death of large numbers of horses and cattle, and whole districts, one might say whole provinces, are depopulated on account of its presence. Yet the part itself is innocent and interesting ; were it not for the parasitic habits of certain lowly organisms it would be quite innocuous. We see this clearly enough when we examine our English relatives of the Tsetse fly, *Stomoxys calcitrans*, *Hæmatobia stimulans*, *H. irritans* and *Prosena sybarita*.

Apart from its character as an organ of destruction the proboscis of Tsetse has interest ; we can trace its development through several stages back to a trophi similar to that on our common larger house fly. In its case, as in all, the rule of the French *savant* Savigni holds good, "the organ is the same in all insects, it is only the use that is changed or modified." By examination of the structures and parts in many species it appears that Tsetse as a species is a comparatively recent addition to our fauna, which has developed a peculiar mouth part for a special purpose. In our larger house fly (*Musca domestica*) the proboscis is a suctorial organ, with the ordinary characters of such a mouth part as found in Diptera, that is to say, the outer and inner jaws (the mandibles and maxillæ) which we find in the gnats (Culicidæ, the breeze flies (Tabanidæ), and other biting insects, have been absorbed into the lower lip (*labium*), and now act as stiffening rods and levers to support the two suctorial discs (*paraglossæ*) at the extremity of the lower lip. The discs or *labella* are fitted with symmetrical rows of trachæ, or tubes formed of chitinous rings.

The lower lip has on its under or ventral surface a chitinous place (the *mentum*) which forms a support. Above the lower lip is the *labrum* or upper lip, which has, however, its base enveloped by the membrane of the lower lip. The upper lip in Diptera is a horny lancet case, which covers a lancet (the *hypopharynx*), which corresponds with the *lingua* or tongue.

The upper lip is furnished with two feeling organs (the *labial palpi*). Till lately these were thought to belong to the inner pair of jaws (*maxillæ*), but the discovery of complete palpi on many species enables me to say with certainty that these are labial, or belonging to the lower lip.

(*To be continued.*)

MONOCHROMATIC LIGHT (*Continued*).

Beyond this, and of greater importance, is the equivalent effect which can be secured with a good achromatic lens—equal, in fact, to that with an apochromatic. All residual colour in the lens is absorbed by the one colour of the light filter, so that the great difference between the chromatic and apochromatic systems, namely, the outstanding secondary spectrum, is thereby abolished.

If all the colours of the spectrum are used in their proper succession to illuminate a given object, it will probably be found that a re-focussing is necessary for many of them, the greatest amount of variation being noticeable usually at the two ends of the spectrum.

Mr. Nelson some years ago prepared a series of charts in which this subject was exemplified with a variety of lenses. In every lens the point of least chromatic aberration is indicated by the focal point remaining practically the same for a continuous range of colour rays. This same point will be the one of least spherical aberration also if the optician has done his best. If, now, a colour screen is selected which approximates to the mean of the portion of the spectrum which exhibits the least difference of focus, and therefore the smallest amount of spherical aberration, the best result would be obtained with the objective.

Before giving formulæ for making fluid monochromatic light screens, the method adopted by Dr. Spitta for obtaining his monochromatic light, as exhibited at the Royal Microscopical Society recently, may be of interest. The following was the system used in the order of arrangement :—

1. Oxy-hydrogen limelight ;
2. A condenser composed of two plano-convex lenses, having placed between them a water bath ;
3. A slit ;
4. An achromatic collimating lens of about 6" focus, composed of a double convex and plano-concave lenses cemented ;
5. A prism, having mounted on one of its faces Thorpe's grating, so arranged as to obtain direct vision for the F line ;
6. A concave lens immediately behind a substage condenser, the object of which is to render the rays divergent, so as to suit the flame distance for which the substage condenser is corrected ;
7. A holoscopic oil-immersion condenser.

Fluid Screens.—One of the most useful screens is that which is known as "Gifford's," and is made by dissolving a few crystals of malachite green in glycerine. The solution is examined spectroscopically with the illuminant that is to be employed, and green is slowly added until the red end of the spectrum is entirely absorbed. It should be noted that a piece of signal green glass in conjunction with this solution materially reduces the thickness of the trough that would otherwise be required. (*To be continued.*)

"THE JOURNAL OF APPLIED MICROSCOPY AND LABORATORY METHODS."

For five years past there has been published at Rochester, New York, U.S.A., a journal with the above title. As this title implies, it is essentially technical and practical.

I have before me a bound volume for the year 1902, and the ground covered by the various articles is very wide and full of interest for microscopists.

The future of microscopy is not dependent on the amateur who only examines ready-prepared micro slides, but on him who practises known methods and endeavours of his own initiative to find better ones. To such this journal in particular appeals.

NOTES AND QUERIES.

J. H. Garnar.—I have not heard of an English edition of Lilljeborg's "Cladocera succiae," and it seems unlikely that such a work will ever be issued. I may mention, however, that at the meeting of the Quekett Microscopical Club on January 16th, Mr. Scourfield brought forward the first part of a synopsis of the British species of fresh-water Entomostraca, in which he dealt with the Cladocera, taking Lilljeborg's book as the work of reference, both for descriptions and figures of the large majority of our species. It seems probable, therefore, that the "Cladocera succiae" will become an indispensable book for British students of these interesting animals, and I certainly have no hesitation in recommending it in spite of its being written in Latin and German, and being somewhat expensive. After all, we in this country ought to be thankful that the veteran Upsala professor did not write his great work in Swedish.

A. W. Comber (India).—It is impossible to advise you as to a course of study which you could pursue on parallel lines with your professional work without knowing the direction in which your tastes and inclinations lie. You would find metallurgical work, that is, the study of the composition and surface of metals, exceedingly interesting, and probably the best book on the subject is Hiorn's, entitled "Metallography." Or perhaps geological and petrological work would prove suitable. You would find a very large and entertaining field in either department.

Roger.—The fractions of an inch by which objectives are designated express approximately the magnifying power or equivalent focus, and not the distance at which they focus from the object. The equivalent focus of an objective divided into 10 gives its magnifying power, thus a 2 inch should magnify 5, a $\frac{1}{4}$ inch 40, and $\frac{1}{8}$ inch, 80 diameters. The troubles you refer to in connecting with your mounting are such as all tyros have to face, practice alone will make you expert. If you cannot obtain guidance from the books you refer to, it would be impossible to give it in a short answer. The assistance of a microscopical friend would probably clear the way.

J. G. Leigh.—Probably the book that would suit you would be Wood's "Common Objects of the Microscope," costing 1s.; or Cooke's "One Thousand Objects for the Microscope," price 2s. 6d.

Communications and enquiries on Microscopical matters are cordially invited, and should be addressed to M. I. Cross, Knowledge *Office*, 326, *High Holborn, W.C.*

NOTES ON COMETS AND METEORS.

By W. F. Denning, F.R.A.S.

Perrine's Comet (1902 b).—This object has now passed beyond the range of ordinary instruments, though it may possibly be still visible in some of the largest telescopes. Mr. F. H. Seares, of the Law's Observatory, Missouri, has computed the following elements:—

PP. 1902, November 23·90094, Berlin M.T.

	°	′	″
ω	154	1	34·4
☊	49	20	11·0
i	156	20	56·1

log. q. 9·612596
log. e. 9·999709.

The form of orbit shows a scarcely perceptible deviation from that of a parabola

Giacobini's Comet (1902 d).—This distant and apparently very small comet continues visible in a good telescope, but its light is gradually declining, and it will soon withdraw from view. At the close of April it will pass near the bright star Castor (α Geminorum), but the comet will be rather a difficult object at about this period in telescopes of moderate size, and will have to be swept for very carefully.

Giacobini's Comet (1903 a).—This comet is considerably brighter than when first discovered on January 15, but its position is too near to the sun for it to be well seen.

Meteoric phenomena have recently been reported as follows:—

February 2, 4 a.m.—A large detonating meteor burst over a point about 2 miles south of Anderson, California, and is described in the *Daily Telegraph*. The roar which accompanied the passage of the fireball startled the townspeople, who ran into the street for safety, thinking that the vibrations were due to an earthquake. Some of the buildings were damaged.

February 2, 6h. 20m. p.m.—Commander Neate, R.N., writes from Dover that he observed a meteor brighter than Venus moving from near the Polar Star to δ Ursa Majoris. The apparition suggested to his mind "a brilliant jewel at the end of a long chain." Duration $1\frac{1}{2}$ seconds.

February 4, 7h. 7m. a.m.—Large and brilliant meteor seen in the west from Yalding, Kent, by Mr. W. Jarvis.

February 12, 6h. 54m. p.m.—Meteor equal in lustre to Jupiter, seen at Liverpool and moving horizontally at an altitude of about 30 degrees in a northerly direction. Alpha Cygni was just below and midway in its course, which occupied about 5 seconds.

Recently in Cape Colony (date not given), "at 10 p.m. a sudden rumbling and hissing noise was heard, and a tremendous ball of fire was seen falling towards the earth, its velocity being so great that it gave the appearance of a burning gash in the sky. As it reached the ground several explosions took place, and next day a large black stone was extracted from a hole 2 feet deep and 2 feet wide, which the body had made."

February 17, 9h. 45m.—Brilliant meteor, giving as much light as the moon in her first quarter, seen at Beckley, Sussex, by Mr. R. Forbes Bentley, but trees hid the latter part of the flight. Observed path from $172\frac{1}{2}° + 20°$ to $195° + 15°$. Duration about 2 seconds.

February 22.—At Ramsay, Isle of Man, there was a very severe gale during which a huge fiery meteor passed over the town lighting up everything like day.

February 26, 7h. 45m.—A large white meteor observed at Hammersmith, W., by Mr. E. Delessert. Its course carried it overhead in a direction from S.E. to N.W., and its approximate flight of 100 degrees occupied 3 to 4 seconds.

April Lyrids.—This shower should be carefully looked for on April 21 and 22, though it seldom furnishes a rich display. This year there will be very little interference from moonlight, so that with clear skies the meteors ought to be favourably observed. Their radiant point, like that of the July-August Perseids, exhibits motion to the eastwards, and as it is essential to obtain more evidence on this point, any earlier and later members of the stream (appearing on April 17-19 and 23-25 respectively), should they be presented, will deserve special notice, and their apparent paths amongst the stars if registered with the greatest possible accuracy will be very valuable.

May Aquarids.—At the end of April and opening of May it will be necessary to watch the eastern quarter of the firmament for the long-pathed, streak-leaving Aquarids first seen by Lieut.-Colonel Tupman in 1870. The radiant point of this shower has never been fully ascertained, and it is hoped that a large amount of new data will be obtained during the ensuing few years.

THE FACE OF THE SKY FOR APRIL.

By W. Shackleton, F.R.A.S.

The Sun.—On the 1st the sun rises at 5.41 and sets at 6.29; on the 30th he rises at 4.39 and sets at 7.17.

The equation of time is negligible on the 16th, this day therefore is favourable for the checking or adjustment of sun-dials by comparison with civil time, since only the correction for longitude need be taken into account. Sun-spots are now of more frequent occurrence, and of late two or more spots have been visible at one time.

The Moon:—

		Phases.	H. M.
April 5	☽	First Quarter	1 51 A.M.
,, 12	○	Full Moon	0 18 A.M.
,, 19	☾	Last Quarter	9 30 P.M.
,, 27	●	New Moon	1 31 P.M.

The moon is in perigee on the 5th, and in apogee on the 19th.

OCCULTATIONS.—The principal occultations visible at Greenwich are as follows :—

Date.	Star Name.	Magnitude.	Disappearance. Mean Time.	Disappearance. Angle from N. Point.	Disappearance. Angle from Vertex.	Reappearance. Mean Time.	Reappearance. Angle from N. Point.	Reappearance. Angle from Vertex.	Moon's Age.
			h. m.	°	°	h. m.	°	°	d. h.
April 3	130 Tauri	5·5	6 47 P.M.	128	102	7 44 P.M.	239	204	5 18
,, 6	A¹ Cancri	5·6	5 46 P.M.	76	102	6 50 P.M.	315	328	8 17
,, 6	A² Cancri	5·8	8 8 P.M.	138	133	9 11 P.M.	259	239	8 19
,, 7	60 Cancri	5·7	0 44 A.M.	81	41	1 34 A.M.	314	275	9 0
,, 9	υ Leonis	4·5	11 48 P.M.	177	161	0 23 A.M.	233	211	11 23
,, 10	B.A.C. 4200.	5·7	9 58 P.M.	95	109	11 8 P.M.	315	315	12 21

There is a very favourable eclipse of the moon on the 11th, when the moon is nearly totally eclipsed. The diagram, projected in the manner described in KNOWLEDGE, October, 1902, shows the path of the moon through the earth's shadow.

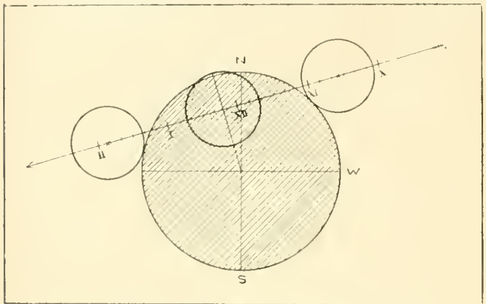


Diagram showing Path of Moon through Earth's Shadow.

The following are the particulars of the eclipse :—

			H. M.
First contact with the Penumbra ...	April	11,	9 28 P.M.
First contact with the Shadow ...	,,	11,	10 34 P.M.
Middle of the Eclipse	,,	12,	0 13 A.M.
Last contact with the Shadow	,,	12,	1 52 A.M.
Last contact with the Penumbra ...	,,	12,	2 58 A.M.

Magnitude of Eclipse (Moon's diameter = 1) 0·973.

THE PLANETS.—Mercury is unobservable during the former part of the month, being in superior conjunction with the sun on the 13th. Towards the end of the month, however, he is becoming well situated for observation, as he sets nearly two hours after the sun.

Venus is now the most brilliant object in the western sky, and shortly after sunset cannot fail to attract attention. On the 1st she sets at 9.17 P.M., and on the 30th about 10.45 P.M., or nearly $3\frac{1}{2}$ hours after the sun. The apparent diameter of the planet is now 12″·6, and the disc presents a fairly gibbous appearance, the illuminated portion being 0·8 of the whole.

Mars is now available for observation throughout the night. On the 15th he is on the meridian at 10.36 P.M., preceding Spica by about an hour. He is describing a retrograde path not far from γ Virginis. The apparent diameter of the planet is 14″·6, whilst 0·985 of his disc is illuminated. The north polar cap of the planet is presented towards us. At 7 P.M. on the 10th the moon will be near to Mars, the planet being about 4° to the north.

Jupiter, Saturn, and Uranus are all practically out of range, rising in the early morning about 4, 3, and 1 A.M. respectively; the latter two are also exceptionally low down in the sky.

Neptune is observable in the evening, and is situated in Gemini; he is close to η Geminorum, being only 4 minutes west and 10′ south of that star.

THE STARS.—About the middle of the month at 9 P.M. the positions of the principal constellations are as follow :—

ZENITH . Ursa Major.
NORTH . *Polaris*; to the right, Ursa Minor and Draco; to the left, Cassiopeiæ and Perseus; below, Cepheus and Cygnus.
SOUTH . Leo and Hydra; to the south-east, Virgo; to the south-west, Gemini (high up), *Procyon* and *Sirius* (setting).
WEST . Taurus, Pleiades and Orion, all rather low down.
EAST . *Arcturus*, Corona, and Hercules; to the north-east, *Vega* rising.

Minima of Algol occur on the 6th at 10.11 P.M., and 9th at 7 P.M.

Chess Column.

By C. D. LOCOCK, B.A.

Communications for this column should be addressed to C. D. LOCOCK, Netherfield, Camberley, and be posted by the 10th of each month.

Solutions of March Problems—(By J. C. Candy).

No. 1.

1. B to Kt6, and mates next move.

Several solvers appear to have overlooked the fact that the Black Bishop defends the QBP. Hence, other moves with the Bishop are unavailing.]

No. 2.

1. R to Kt3, and mates next move.

SOLUTIONS received from "Alpha," 0, 2; W. Nash, 2, 2; G. A. Forde (Capt.), 0, 2; W. Jay, 2, 2; "Looker-on," 2, 2; A. H. H. (Croydon), 2, 2; W. H. S. M., 2, 2; G. W. Middleton, 2, 2; "Tamen," 2, 2; "Quidam," 2, 2; J. W. Dixon, 2, 2; C. Johnston, 2, 2; H. F. Culmer, 0, 2; G. P. Burns, 2, 0.

W. Geary.—Very many thanks. Two of them will appear next month, and the remainder during the summer.

G. P. Burns.—In No. 2, if 1. P to R6, B to K3; if then 2. Kt to K4, B to R7, or if 2. P to R7, B to Q4. 2. Kt × B is, of course, stalemate.

Hamilton White.—Please send the actual solution of your end-game. There is a mate in seven moves in which all Black's moves are not forced. I am uncertain, therefore, whether this is your intended solution.

H. F. Culmer.—Thanks for the problem; I fear, however, that it would never do to use in a solution tourney a problem which has already been published.

"*Quidam.*"—I am forwarding your complaint as to lateness of delivery, and hope that the matter may be remedied in future.

"*Tamen.*"—Please see reply above. You must understand, however, that rules cannot be relaxed to suit special cases, otherwise there might be no limit to the number of extenuating circumstances which might be urged.

A. H. H. (Croydon).—Many thanks for the problem. I will examine it, but cannot say for certain in what number it will appear.

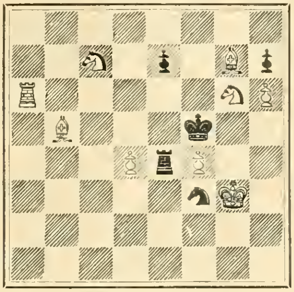
SOLUTION TOURNEY.—The leading scores at present are :—J. W. Dixon, C. Johnston, W. Jay, "Looker-on," W. H. S. M., W. Nash, 22; "Quidam," 19; G. W. Middleton, 18; "Endirby," 18 (no solutions received this month).

PROBLEMS.

By C. D. Locock.

No. 1

Black (5).

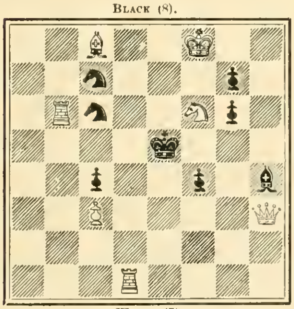


White (9).

White mates in two moves.

No. 2.

Black (8).



White (7)

White mates in two moves.

After this number I shall hope to give at least one three-move problem every month.

"KNOWLEDGE" PROBLEM TOURNEY.

After careful consideration I have placed the eight problems, selected by the more successful solvers, in the following order :—

1st *No.* 12, "*Ariadne*."—A problem with many beautiful points. The key, perhaps, is rather more "take" than "give," but as Black could evidently not take the Knight where it stands, I cannot consider it weak. Three out of the four continuations are quiet, one being a Queen sacrifice. Very pretty is the successive visitation of Q3, QB3, and QKt3, and the use of the Black Bishop to block the King in two different mates. It is a pity that a third attempt of this kind results in a dual or triple mate. Very pleasing too is the distant action of the White Bishop, with its one "Ruy Lopez" mate. The great variety after 1. . . . B × P is probably due to the fact that the problem, though it simulates a "block," is in reality of the "threat" class. Q to R8 is a good "try," the White King being cleverly used to prevent its becoming too good. Q to KKt3 and P to B4ch are also fair "tries." Every piece, and one of the rather numerous White Pawns, gives a mate.

2nd. *No.* 26, "*Ben trovato*."—An ideal light-weight problem. The substitution of a Rook (which mates on three different squares) for the customary Knight or Bishop is most refreshing. The key is distinctly difficult, and good to the extent of giving additional freedom to the Black King. Of the six continuations two are quiet, though confining, and many of the mates are good, while none are absolutely commonplace. The one weak point is the uselessness of the White King. Its position may serve to call attention from the key, but its proper place, if possible, was at QR8, removing one of the Black Pawns. But for this the economy is almost perfect. The White Knight is curiously stationary throughout.

3rd. *No.* 10, "*Possibilities*."—A very pretty position. The two continuations with the Knight, which makes the key, are in excellent style, and P to B3 is a subtle defence to the threat. Some of the mates are admirable. There is rather less variety than in the other prize-winners. The composer probably found some difficulty in stopping a dual, but in other respects the construction is first-rate.

4th. *No.* 18, "*Bargany*."—A slashing problem, with much bloodshed on both sides. I cannot consider the key good. Though the Rook is offered it was already *en prise*, and the square given to the Black King is not sufficient compensation for the square of which he is robbed. The threat is, nevertheless, not obvious, and results in a great variety of rather inferior mates. The two main variations, involving the sacrifice of Queen and Rook, are very brilliant; other continuations are moderate, and lead to mating positions in which one or more of the White pieces have no part. There are some dual mates in two of the variations. The economy of White force is by no means satisfactory, and only three of the mates are at all pure and economical. Particularly annoying is the position of the Black Knight when the King is mated at K5, and of the Pawn at Kt3 when he is mated by Kt to Kt7. The White King guards one square in one continuation, but takes part in no mate. This problem was easily first in the estimation of our solvers. For this reason I have, in these remarks, dwelt more on what seem to me its defects than on its many good points.

Equal 5th. *No.* 13, "*Leonard*."—Distinguished above all others for the purity and economy of the mates. The key is good, followed, as it is, by a quiet threat; though the piece to move is, perhaps, rather obvious. There is a fine try by 1. Kt to B5. But for the unfortunate dual after K to Q3 this problem would probably have been a prize-winner. As it is, it must be content with honourable mention.

Equal 5th. *No.* 4, "*Three Steps and a Shuffle-off*."—A well-constructed diagonal flight-square problem of not unfamiliar type, with three quiet continuations and some very nice mates. The key lacks difficulty, and, moreover, deprives the Black King of what was clearly his best chance of ultimate escape. The economy is of course quite faultless.

7th. *No.* 24, "*Weighty*."—An ingenious "block," but Black's threatened check and the position of the Black Bishop both aid in the quick discovery of the key, the brilliancy of which is somewhat discounted by the fact that the Queen is out of play. The subsequent continuations, including the Queen sacrifice, strike me as a little obvious ; the best variation follows on 1. . . Kt × Q, which leads to two capital mates. The remaining variations are only of a moderate character, and more than one White piece is generally "looking-on" at the mate. Q × P and B to Bsq are fair "tries."

8th. *No.* 6, "*Trifolium duplex*."—The main feature consists in the mates given by three White Pawns, in one case by promotion. The key would be good if it did not threaten a mate on the move, and Black is provided with

an abundance of defences. The Queen sacrifice leads to a pure mate; but even here three White pieces, besides the King, are mere spectators. The other mates are for the most part very impure. Altogether the position is greatly overcrowded, and the absence of a second solution is really surprising.

The best of the other sound problems, mentioned in order of publication, are, I think, No. 1, "Per Aspera ad Ardua"; No. 9, "Satis" (a good problem, but our solvers evidently will not stand the minor duals inseparable from compositions of the German school); No. 17, "Brutum Fulmen"; No. 22, "By indirection, etc." (very good but for the triple continuation after 1. . . B to B6); No. 23, "Seeing the thing through" (a very clever and original piece of work, but the key is weak, and, again, the minor duals were against it), and No. 25, "Inter Pocula" (*see* note on No. 9).

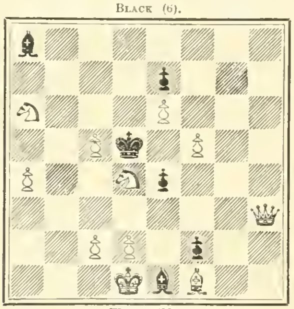
Of the unsound problems, No. 2, "Fort Nachanand," was a truly magnificent conception, the "race of the Knights" being distinctly humorous. No. 11, "With how much labour, etc.," was also a fine problem, the composition of the winner of the last KNOWLEDGE tournament.

On opening the sealed envelopes, I find that the following are the prize-winners. The award, as usual, will remain open for one month.

FIRST PRIZE.—"Ariadne."

By G. Heathcote (Manchester).

BLACK (6).



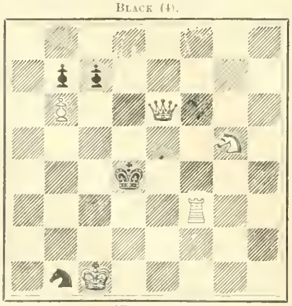
WHITE (11).

White mates in three moves.

SECOND PRIZE.—"Ben trovato."

By W. GEARY (London).

BLACK (4).



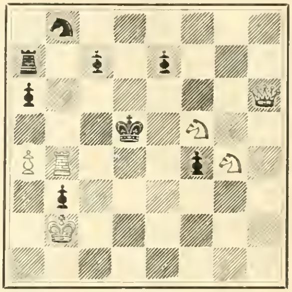
WHITE (5).

White mates in three moves.

THIRD PRIZE.—"Possibilities."

By H. F. W. Lane (Stroud).

BLACK (8).



WHITE (6).

White mates in three moves.

The following problems (given in Forsyth notation) obtain honourable mention:—

No. 18. "Bargany" (F. W. Wynne, Dudley)—2 B 1 N 1 K 1, 1 r 1 p p 3, b R 4 p 1, 3 k 4, Q 1 p 2 P p 1, 1 R 2 B n 2, 8, 8.

No. 13. "Leonard" (B. G. Laws, London)—4 K 2 b, 1 p 5 P, 1 P 6, 3 B k 3, 1 p P 1 N 3, 5 Q 2, n 1 P 5, 8

No. 4. "Three steps and a shuffle-off" (G. J. Slater, Liverpool) 8, 8, 4 p 3, 1 P k 1 N 2 Q, 8, 2 N 5, 8, 2 K 5.

The composers of the remaining problems were as under: those marked with an asterisk proved to be unsound. 1, P. L. Osborn (London); 2,* K. Erlin (Vienna); 3, E. G. B. Barlow (Surbiton); 5,* E. Palkoska, (Bohemia); 6, R. J. Bland (India); 7,* J. Möller (Denmark); 8, A. P. Bree (Jersey); 9, J. Jesperson (Denmark); 11,* A. G. Fellows (Watford); 14, Rev. R. J. Wright (Worthing); 15,* H. W. Schmidt (Honolulu); 16, V. de Barbieri (Russia); 17, Horace Pitt (Cardiff); 19, J. W. Dawson (Grimsby); 20, Max J. Meyer (Boscombe); 21,* R. H. Andrews (Jersey); 22, Percy Healey (London); 23, J. W. Abbott (London); 24, P. G. L. F. (Twickenham); 25, R. Hollstein (Berlin).

It is rather remarkable that no Continental composer received a single vote from any of the solvers who acted as preliminary judges.

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CONTENTS.

FAMILIAR BRITISH WILD FLOWERS AND THEIR ALLIES.

By R. Lloyd Praeger, B.A.

III.—THE UMBELLIFERÆ.*

Among the larger wild flowers which one meets on a country ramble, none are more familiar than the members of the group which botanists call the *Umbelliferæ*, or umbel-bearing plants. These plants are puzzling to the beginner on account of the strong family likeness which runs through the majority. In a large number of the commoner species we find the same strong erect growth, hollow, branched stem, much-divided leaves triangular in outline, and flattish white or pink compound umbels formed of numerous small flowers. Indeed, were stem and leaf the only means of discrimination, identification would be difficult; and if we had to rely on the flowers alone, well nigh impossible. But the fruit of these plants, remarkable in structure, is also much varied in form. Here we have the key to their classification; and a study of the fruits of the *Umbelliferæ* will not only enable the beginner to name his plants, but will present to his view a large series of interesting and beautiful forms. Each fruit consists of two carpels (*mericarps*), often flattened, adhering by their face (*commissure*) to a common axis (the *columella* or *carpophore*), from which they ultimately separate and become pendulous. Each carpel has usually five longitudinal ribs, and often four lesser ribs alternating with these; and in the substance of the wall of the fruit, either under the ribs or in the spaces between them, there are often canals (*vittæ*) filled with essential oil. The mericarps vary in shape, in the character of the ribs, and in the arrangement of the vittæ, and these variations generally render identification easy. If the fruit be cut across horizontally with a knife, its characters are seen to the best advantage. The accompanying sketch shows enlarged sections of the fruits of five familiar Umbellifers, and exemplifies the variety of form and arrangement that has been referred to.

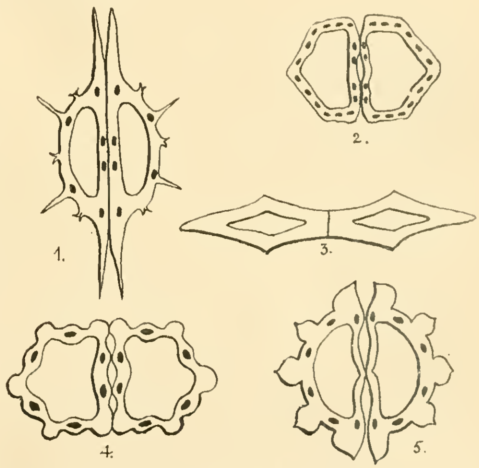


Fig. 1.—Horizontal Sections of Fruits of *Umbelliferæ*. 1. *Daucus Carota*. 2. *Pimpinella magna*. 3. *Hydrocotyle vulgaris*. 4. *Carum Carui*. 5. *Æthusa Cynapium*. Enlarged.

The *Umbelliferæ* are a large order of plants, comprising several thousand species. They are represented in every part of the world, but are especially abundant in Europe and temperate Asia. The species which are reckoned as native or naturalized in the British Islands number sixty-nine, distributed among forty genera; from which figures it may be gathered that a quite unusual number of genera—thirty, to be precise—are with us represented by a single species only. Our British *Umbelliferæ* are all herbaceous plants, but in other parts of the world shrubby species occur, and others again which widely differ in general appearance from the Carrot- or Parsnep-like forms which we are inclined to regard as typical of the order.

Among the British *Umbelliferæ*, some few have inflorescences differing from the characteristic form, the flowers being arranged in simple instead of compound umbels, or in head-like groups. These plants belong to the genera *Hydrocotyle* (Marsh Pennywort), *Sanicula* (Wood Sanicle), *Astrantia*, and *Eryngium* (Sea-Holly); and it will be seen, when we come to speak of the

* For the use of the blocks which form Figures 2 to 6, the writer is indebted to Messrs. C. Griffin & Co. They are taken from his "Open-Air Studies in Botany."

characters of the British representatives of the order, that these genera depart from the usual plant-form of the *Umbelliferæ* in other respects also.

As a group, the *Umbelliferæ* are remarkable for the powerful secretions produced by many species. They are a strong-smelling and strong-tasting order, some useful, many highly poisonous. Among the British species, good exemplifications of both characters are found. Conspicuous among the noxious species are the Hemlock (*Conium maculatum*), and the various species of Water-Dropwort (*Œnanthe*). The poison in these plants is narcotico-acrid, producing delirium, palsy, and asphyxia. The Water-Hemlock (*Cicuta virosa*) is equally dangerous, producing effects similar to those of prussic acid—tetanic convulsions, ending fatally. Others of our British species lose their acidity by cultivation or bleaching. Thus we get our

FIG. 2.—The Samphire at Home.

R. WELCH, *Photo.*

Carrots and Parsneps, the enlarged tap-roots of species of the genera *Daucus* and *Pastinaca*. The esculent Celery is produced by bleaching the leaf-stems of *Apium graveolens*, a common inhabitant of salt-marshes. The Parsley of our gardens is a curly-leaved form of *Carum Petroselinum*, a plant of unknown origin, which readily escapes and makes itself at home, as a coarse strong-growing plant, on old walls and limestone rocks. Of useful species not in cultivation, the best known is the aromatic Samphire (*Crithmum maritimum*), a plant of the sea-rocks, which makes a delicious pickle. The succulent roots of Sea-Holly (*Eryngium maritimum*) and Angelica (*Archangelica officinalis*) are sometimes candied, and have medicinal properties. The well-known Caraway seeds are the aromatic fruits of *Carum Carui*; and the fruits of Anise (*Pimpinella Anisum*), Coriander (*Coriandrum sativum*), and others, have similar properties.

The British *Umbelliferæ*, nearly seventy in number, form too large a group to permit of a survey by genera and species within the limits of a single article. We may, instead, take up in turn each part of the plant, note its characteristic form or forms, and consider any striking departures from this form which our British species present. First, then, as regards roots and root-stocks. A characteristic form among the *Umbelliferæ* is the tap-root, as we see made fleshy by cultivation in the Carrot. Others, such as the Whorled Caraway and some species of Œnanthe, have a bunch of fleshy fibres, largest near the extremity. *Carum Bulbocastanum*, a rare English species found chiefly near Cherry Hinton, has a brown sub-globular tuber. In the Pig-nut, *Bunium flexuosum*, a common spring woodland plant, the tuberous form is more pronounced, being of irregular shape and comparatively deeply buried; it is sweet and nut-like in flavour, as all of us who have spent our childhood in the country well know. The Sea-Holly possesses far-creeping succulent root-stocks, which burrow deep in the sea-sands, and send up shoots into the light and air above.

The stems of our Umbelliferous plants do not present any great range of form. The upright branched hollow stem of the Wild Chervil (*Chaerophyllum sylvestre*) or Gout-weed (*Ægopodium Podograria*) may be taken as a type. In our larger species, such as the Cow-Parsnep (*Heracleum Sphondylium*) or Wild Angelica (*Angelica sylvestris*), these stout hollow stems, like pillars, designed to bear the weight and stress of the large spreading leaves and umbels, form striking and interesting examples of plant architecture. At each node a solid partition extends across the column, and at the places thus strengthened arise the leaves and axillary branches. In the Marsh Pennywort (*Hydrocotyle vulgaris*) the stem is strikingly different, being weak and creeping, emitting rootlets on one side of each node and leaf and flower-stems on the other. Several other marsh species by their decumbent habit and rooting at the nodes connect this extreme form with the more typical kind of stem. The Samphire, alone among our British species, can produce a perennial elongated woody stem from which annual branches arise.

The leaves of the *Umbelliferæ* are usually characteristic—large, triangular or oblong in outline, and much divided. Sometimes they are long and simply pinnate, as in the Parsnep (*Pastinaca*), Burnet Saxifrage (*Pimpinella*), and Water-Parsnep (*Helosciadium*), but more frequently bipinnate or tripinnate, with finely cut segments; in some cases the final divisions are hair-like, as in the Fennel (*Fœniculum officinale*) and Bald-Money (*Meum Athamanticum*); in other cases, ovate-serrate, as in the familiar Wild Angelica. In the sea-haunting Samphire the linear

segments are glaucous and fleshy, as is characteristic of halophytes, or plants which grow in places charged with salt. In the Whorled Caraway (*Carum verticillatum*) the leaves are pinnate, the pinnæ dividing into numerous hair-like segments which, instead of lying in one plane as in most leaves, spread out all round the leaf stem, like the whorls of the Lady's Bed-straw, making the outline of the leaves cylindrical. The genus *Bupleurum*, or Hare's-ear, includes several slender herbaceous plants, in the British Islands confined to southern England, which are rendered very unlike most of their allies by their simple lanceolate leaves. One species, *B. rotundifolium*, has broad pointed leaves which completely embrace the stem—a unique form among our British *Umbelliferæ*. The aberrant simple-umbelled group which has before been referred to differ from the type in their leaves as well as in their inflorescence. The Marsh Pennywort has peltate leaves like those of the true Pennywort, *Cotelydon Umbilicus*—round in outline with the stalk inserted in the middle. *Sanicula* and *Astrantia* have pretty palmate leaves—a number of segments springing from one point, like a fan. Many of the *Umbelliferæ* are, no doubt, protected from the attacks of feeding animals, large or small, by the virulent or acrid properties residing in their leaves and stems. In one, the Sea-Holly, recourse is had to a device familiar in other families—the production of an armament in the form of spines. In this species, too, which lives on the dry burning sea sands, the leaves are grey and leathery, and protected by thick layers of cells from too great transpiration.

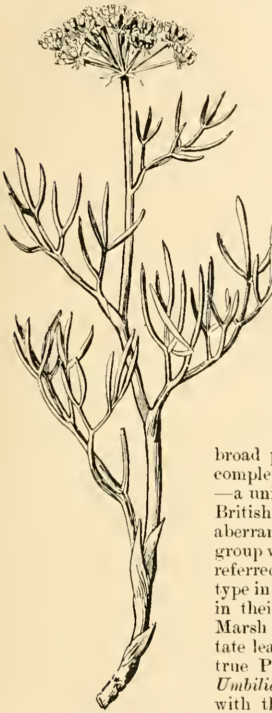


FIG. 3.—Samphire (*Crithmum maritimum*). Half natural size.

Next we come to the flowers, which, as already stated, are usually arranged in compound umbels. That is, the flowering stem divides into a number of branches which spring from one point and reach about the same level; at which level each branch again similarly divides, each division bearing a terminal flower. The result is a large circular flattish surface of blossoms. The advantage to the plant of such an arrangement is that it renders the inflorescence conspicuous—advertises the flowers to the honey-feeding insects, which come and by their visits carry the pollen from plant to plant. In all our *Umbelliferæ*, each flower is quite small; but the result of this aggregation is a most conspicuous inflorescence. Moreover, the outermost flowers of the umbel are often irregular, their outer petals, which alone of all the flowers have room for expansion, being considerably enlarged, thus further assisting to render the flower-mass conspicuous. We may note the same device carried still further in the flat flower-masses of the Guelder-rose, *Viburnum Opulus*, which belongs to an allied order. In this shrub the petals of the outer flowers have been developed at the expense of the essential organs, and these outer blossoms consist merely of a large white corolla—a pure advertisement—while all the business of the plant is carried on by the comparatively inconspicuous flowers which are massed in the centre of the cluster. The flowers of the *Umbelliferæ* are of simple structure. There is little room or need for a calyx, and it is adherent to the ovary, and its free part, which forms the conspicuous protecting sepals in so many flowers, is wanting. The small petals are five in number, wide-spreading, notched, usually of light colour—white, or less commonly pink or yellow. The stamens are five, long and spreading between the petals. The middle of the flower

FIG. 4. The Sea-Holly at Home.

R. WELCH, *Photo.*

is occupied by a disk in the centre of which rise two styles. The honey lies open to all comers. There is no guarding of the approaches to the flower, or to the nectary; no

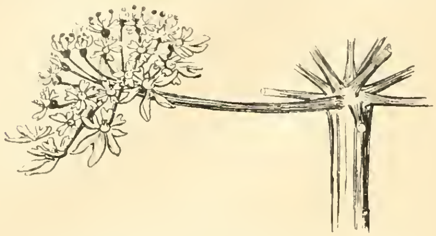


Fig. 5.—Secondary Umbel of Cow-Parsnep, showing large exterior petals. Two-thirds natural size.

provision for the visits of any particular kind of insect. In consequence, all kinds of insects visit the flowers—flies, beetles, bees, moths, ants—both flying and crawling creatures.

The umbels are generally terminal on the branches, but in a few cases axillary, as in the Water-Parsneps (*Helosciadium*) and the Knotted Hedge-Parsley (*Caucalis nodosa*). Compound umbels are found in the majority of the British species, but sometimes the umbels are simple, as in the Venus's Comb (*Scandix Pecten-Veneris*). The number of rays which go to compose the umbel varies greatly, being reduced in some species to two or three, thus forming irregular small clusters of flowers, instead of large disk-like masses. The Marsh Pennywort, already referred to, which has creeping stems from which arise circular peltate leaves, has flower-stems much shorter than the leaves, and quite hidden by them. These peduncles terminate in little clusters of pinkish minute flowers. In *Astrantia*, a quite abnormal effect is produced by the petal-like character of the leaves of the involucre. The involucre is the ring of small leaves which, more or less developed, surrounds the point where the branches of the umbel radiate from the stem. In some plants, as in the Wild Carrot, this involucre is a conspicuous feature, forming a ring of much divided hairy foliage; in a few species it is altogether wanting. In *Astrantia* the umbel

Fig. 6.—Flower-head of Sea-Holly, with Involucre (half natural size), and Single Fruit with Bract (× 2).

is simple, with very numerous rays. The segments of the involucre are longer than the rays of the umbel, and are undivided and erect, surrounding the inflorescence and giving it the appearance of the flower-head of one of the Daisy group of the *Compositæ*. In some of the species, as the pretty *A. carniolica*, the colouring of the involucre adds to the illusion. The Sea-Holly has also an abnormal inflorescence, in which the primary umbel consists of a terminal shoot and several spreading branches arising from one point, and surrounded by an involucre of three leaves, while the secondary umbels which these bear are reduced to egg-shaped heads of flowers, with conspicuous spiny blue involucres, and also a spiny bract below each flower. The Sea-Holly is quite one of the most remarkable as well as one of the most beautiful of our British *Umbelliferæ*. Its leathery, glaucous, spiny foliage, tinged with vivid blue, and heads of blue flowers, are unique features among the numerous native plants of this order.

Of the characteristic fruit of this order something has already been said. It consists of two single-seeded carpels attached by their faces to a common short forked axis; when ripe the faces separate from the axis, the carpels remaining attached and pendulous by their upper extremity. The carpels are sometimes laterally compressed as in Marsh Pennywort (*see* Fig. 1); sometimes dorsally compressed as in the Wild Carrot (*see* Fig. 1); sometimes smooth, often strongly ribbed; sometimes covered with spines. The fruit is usually devoid of any obvious provision to assist its dispersal. When ripe and hanging lightly from the carpophore it is easily detached; the upright stems of the plants are often stiff and elastic, and spring back into position if moved by a passing animal or by the wind. The fruits may often by this means be projected to some distance, in the manner of other catapult-fruits.

The fruits of some, as the Wild Angelica, are broadly winged and may be carried to some distance by a high wind; but in very few cases is there any character which suggests wind-carriage. Of more obvious use are the hooked bristles with which the fruit of some of our *Umbelliferæ* is set. Some of the species of Bur-Parsley, *Caucalis*, for instance, have their fruit thickly beset with hooked bristles, liable to become entangled in the coats of passing animals, and thus secure a wide dispersal. The fruit of the Wood Sanicle is similarly furnished. A curious case is furnished by the Knotted Hedge-Parsley (*Caucalis nodosa*), which bears small almost sessile lateral umbels. The inner fruits of each cluster are smooth, while the outer mericarp of the outer fruits alone is furnished with numerous rows of hooked bristles which are clothed with backward-pointing teeth. The fruit of other species of *Caucalis*, and of the Wild Carrot (*Daucus Carota*) possess an abundance of straight spines which may act in the same way as has been just described. The fruit of the Venus's Comb (*Scandix Pecten-Veneris*) is very curious. The mericarps and carpophore to which they are attached are prolonged into a great beak, which far exceeds in length the fruit itself, attaining sometimes a length of three inches. This beak is furnished with forward-pointing bristles. The low growth of the plant renders it unlikely that its dispersal is assisted by fruits entangled in the fleece of animals, and the object of the remarkable beak is not apparent. In the Sea-Holly, the calyx limb is present—a very rare feature in this order—as five stiff lanceolate segments. These are persistent and crown the rough fruit, and possibly in some measure assist its dispersal (*see* Fig. 6). But though the majority of the *Umbelliferæ* apparently trust to "chance" for their advance into new ground, they still apparently secure a sufficiently wide dispersal, as shown by the abundance of many of the annual and biennial species.

THE PALÆONTOLOGICAL CASE FOR EVOLUTION.

By R. Lydekker.

(*Continued from page 76.*)

It will be well, before proceeding further, to sum up very briefly the palæontological case for evolution so far as the five main branches (or phyla, as Professor Osborn would prefer to call them) of the vertebrate stock are concerned.

With regard to mammals the evidence is practically decisive and complete as to an intimate connection with (and therefore their probable descent from) reptiles. And the same is true with regard to the affinity between reptiles and salamanders. So far as a direct connecting chain is concerned, salamanders indeed cannot be affiliated to fishes, but the collateral, or what may be termed circumstantial, evidence points most strongly to the former existence of such connecting links, and consequently to the evolution of the former from the latter group. Very much the same may be said concerning the resemblances between birds and reptiles.

Although the gaps in the fish-salamander series are still very large, and we are unable to show at present any intermediate form between reptiles and birds, it is important to notice that in not one single instance is there a scrap of evidence which could be construed as detrimental to the evolution doctrine. Such evidence as there is, be it full or be it sparse, in every instance points, so far as it goes, to the derivation of the newer from the older, of the higher from the lower, of the specialised from the generalised.

To revert to mammals, it was mentioned in the course of our remarks on the relationship of that group to the anomodont reptiles that some at least of the small mammalian jaws from the Stonesfield slate and other Jurassic formations, as well as those from the Cretaceous, not improbably indicate the ancestors of mammals other than the modern monotremes. It has been very generally considered that many or all of these Mesozoic mammals were marsupials, but recent changes in our conception of the nature and origin of the latter group have tended to discredit this idea. And the probability is that none of the Mesozoic mammals were marsupials, or at all events not marsupials as we now know them. Far more likely is it that these early mammals—the presumed direct descendants of the anomodonts—laid eggs and approximated in the characters of their skeletons to the modern monotremes. Together with the direct ancestors of the latter (which, as already mentioned, there is some reason to believe may have had a peculiar type of dentition inherited from a special branch of anomodonts) they not improbably formed a primitive group for which Huxley's name of Prototheria is available.

All this is, however, more or less vague conjecture, and it is time to return to facts. Apart, then, from these small Mesozoic forms of which the affinities are unfortunately so uncertain, the most primitive, and, at the same time, some of the earliest (if not actually the earliest) Tertiary mammals with which we are acquainted are the so-called Creodontia, or primitive Carnivora. These creodonts, which varied in size from that of a small fox to that of a bear, were long-jawed mammals, with a dentition of a carnivorous type, but lacking the differentiation of a pair of teeth in each jaw into special cutting instruments—the carnassial, or flesh, teeth of cats and dogs and most other modern land Carnivora. That the creodonts were the direct parents of the latter is now generally admitted by palæontologists,* and it is likewise highly probable that they also gave rise to the Insectivora (shrews, hedgehogs, tenrecs, etc.).

That they were not marsupials (that is to say in the ordinary restricted acceptation of that term) may be regarded as well established; but certain more or less nearly allied forms from the Tertiary deposits of South America appear to indicate such a complete transition from the typical creodonts to the carnivorous marsupials as to render it seemingly very difficult, if not indeed impossible, to draw any satisfactory distinction between the two groups.

* *See* J. L. Wortman, *American Journal of Science*, 1901-2.

And here a few words may be devoted to certain peculiarities in the organization of modern marsupials. In common with the great majority of mammals other than marsupials, the creodonts develop two series of teeth —a small milk, or baby, series, and a larger permanent series, the anterior members of which vertically replace the former as they are shed. Marsupials, on the other hand, if they change any teeth at all, change only a single pair in each jaw, and considerations into which we need not now enter render it probable that their restricted tooth-change is what naturalists call a specialised, and not a primitive feature. In other words, it appears that marsupials have lost the complete tooth-change characteristic of most other mammals, and not that they have only commenced to develop the same. Similarly, recent investigations tend to show that marsupials, like the higher mammals, formerly produced their young with the aid of the structure known as the placenta, of which some of them still retain a vestige. Further, modern marsupials are characterized by the presence of unossified spaces in the bony palate of the skull, and likewise by a peculiar bending-in of the hinder part of the inferior border of the lower jaw—the inflection of the angle of the lower jaw, as it is technically called.

Now the extinct South American mammals referred to above differ from the typical creodonts in replacing a smaller number of teeth, showing in this respect a complete transition from the former to the true marsupials, in which, as already mentioned, only a single pair in each jaw is thus replaced. They show, moreover, the marsupial inflection of the lower jaw, although they lack, in most cases at any rate, vacuities in the palate. As to the presence or absence of a placenta, nothing can of course be said, as indeed is the case with the typical creodonts.

So far as the available evidence goes, these South American sparassodonts, as they are called, seem to justify the statement that between the creodonts on the one hand and the carnivorous marsupials on the other there is such a close connection that (here and elsewhere on the assumption that evolution is the true explanation of the resemblances of animals to one another) there seems every reason for regarding the one group as descended from the other, or both as divergent branches from a common ancestor.

This being so, the question narrows itself as to whether creodonts are more primitive than marsupials. *Primâ facie*, the inflection of the lower jaw and the presence of vacuities in the palate, might apparently be just as well acquired as primitive features; but since the former feature occurs in some of the Jurassic mammals it would seem to be primitive. Both characters may, however, have been lost in the more typical creodonts with which we are acquainted. On the other hand, if, as is generally believed, the reduced tooth-replacement in marsupials is due to degeneration it is manifest that in no sense can the latter group be ancestral to creodonts. And the same seems to be demonstrated by the vestigial marsupial placenta, even if creodonts were non-placentals. The balance of evidence thus seems to be in favour of the derivation of marsupials from creodonts.* It should be added, however, that this is not the view of Dr. Wortman, who has made a special study of the latter group. In his opinion marsupials are not the descendants of placentals, but, together with creodonts, are the derivatives of a non-placental stock. This leaves unexplained the origin of the marsupial vestigial placenta.

* It has been stated that one of the Jurassic mammals had a reduced tooth-replacement like that of modern marsupials, but the minute size of the specimen renders the evidence indecisive.

Be the exact relationship between the creodonts and the marsupial carnivores what it may, the evidence fully justifies the belief that the two have a common ancestry, and that the latter have given rise to the herbivorous members of the same great group. The most generalised marsupials now living appear to be the American opossums, which we know from fossil evidence to be an ancient family; and it is believed by some that the arboreal type of foot possessed by these animals was a feature of the ancestral marsupial stock. It follows from this (if it be well founded), that if marsupials are derived from creodonts, the ancestral members of the latter group must likewise have possessed feet of the arboreal type, but there is no evidence that such was the case.

It has thus been shown that, apart from details, palæontology enables us to refer such widely divergent groups as the modern marsupials and carnivora, as well probably as the insectivora, to a common ancestry; the ancestral type being not improbably represented by the early Tertiary creodonts, or by nearly allied forms which may have existed at a still earlier epoch.

But the importance of the creodonts does not by any means end with their resemblances to the true carnivora on the one hand and to the carnivorous marsupials on the other. They are equally nearly related to the early Tertiary ancestors of the modern ungulata or hoofed mammals, the so-called condylarthra of the American palæontologists. And, indeed, the great difficulty connected with the study of the early Tertiary mammals of all kinds is not to discover relationships, but to point out differences; all the modern ordinal groups appearing to merge more or less completely into one another at that comparatively early epoch of mammalian history. To describe the generalised character and mutual resemblances of these early Tertiary mammals in an article like the present would, however, be difficult as well as wearisome, and it must suffice to record the important fact that the further we recede in time from the present epoch, the less differentiated become the different groups of mammals.

(To be continued.)

ST. SOPHIA, CONSTANTINOPLE.

By E. M. ANTONIADI, F.R.A.S.

Illustrated from original drawings by the Author.

IV.

WE have seen that a representation of the sky itself was deemed the only vaulting worthy of Justinian's church; and it now remains to show that it was not really possible to imitate the firmament, with brick and mortar, better than we find it realized in St. Sophia. A flattened dome, resting on emptiness, is the general impression which the sky leaves to mankind. But the impossibility of a close architectural reproduction of that impression necessitated an appeal to indirect methods; and thus was it that a recession of the supports became the only available structural equivalent of empty space.

In this connection, it is important to remember that any increase in number of the supporting arches entailed a corresponding diminution in the projection of the pendentives; and that the concomitant effect tended to defeat, in some measure, the very idea of the dome, first by exaggerating the visibility of its supports, and then by causing it to rest directly on earth, through an uncouth cylindrical drum or tower. Considerations like these must have been always present in the mind of Anthemius; and his solution of the problem was stamped with that direct simplicity so characteristic of the master mind. He obtained the "flattened" appearance by limiting to 108°* the arc subtended by the cupola, whose height thus equalled only one-fourth of its diameter; and he secured a maximum of aeriality to the supports by increasing the projection of the triangular pendentives to a maximum, and by limiting to a minimum of four the number of supporting arches. The gentle, but forcible, lightness of the effect produced by those lofty walls, so boldly projecting into space, is further enhanced by the vast expanse of the semi-domes to east and west and the arches to north and south, undermining, so to say, on all points the effective supports of the hemisphere. Resting thus everywhere on sharply receding surfaces, and further alleviated by forty windows opened at its base, the lofty dome of St. Sophia has well remained to this day the most successful architectural approach to the air-borne vault of the universe.†

A restoration of the eastern bay of St. Sophia, prior to 1204, is given in Plate II. The view point is the same as in Plate I., but the angle embraced is much smaller; and, in order to show as clearly as possible the details of the choir, the confusing ocean of lamps has been to a large extent eliminated.

In the centre we find the Ambo, from which the Gospel was read, and where the Greek emperors were crowned.‡ Much uncertainty is veiling the form of the pulpit,§ and the representation here given of it does nothing to clear matters. The Ambo has been drawn out westwards in

* This value was increased to 160° in the reconstruction.

† It is perhaps unnecessary to revert to the fact that the cross, mentioned by the poet, towered majestically above the dome, as the logical coronation and trophy of the Great Church of Christendom; and that the All-Ruler (Παντοκράτωρ) adorned in mosaic the inner circular crown. The arguments given by the writer on pp. 30, 84 and 91, which lack of space has rendered laconical, have established these truths on a strong basis. Still some additional evidence would not be out of place here. Three hundred years after the second dedication of St. Sophia, Basil the Macedonian raised a large and beautiful church in the palace of Constantinople, and we hear from the patriarch Photius that no cross, but a Pantocrator, was depicted inside the dome of the new church. Considering that St. Sophia was the standard for imitation, and that its example was law in such matters, the fact mentioned by Photius assumes the force of a grave objection to Mr. Burkitt's theory that the cross was inside, and that the dome of St. Sophia, destitute of its outer cross, looked very much like a modern astronomical observatory. But it is possible to bring forward arguments of a much more decisive character against that artificial position. Du Cange, whose extraordinary accuracy caused him to write nothing without proofs, says:—"In interiore tholi. . . centro. . . Iustinianus opere musivo Christum in iride sedentem, orbem judicantis effigie, describi curavit, ut αὐτόπται testantur" (*S. Sophia*, § 33). What more can we ask, as corroboration of the fact that the Pantocrator was originally in the dome, than this proof of ocular witnesses?

Notwithstanding this converging evidence, perhaps the strongest proof that the cross was outside is afforded by an examination of the Silentiary's poem. If, as suggested by the writer (on the authority of Homer, Il. P, 599-600: "γράψεν δέ οἱ ὀστέον ἄχρις αἰχμὴ Πουλυδάμαντος." "and the lance of Polydamas *cut* him as far as the bone"), ἔγραφε was used by the Silentiary as meaning *incised*, *carved*, it would then be probable that the same sense may occur more clearly in another part of the poem. Checking our anticipation by the evidence of the hexameter, we find it verified to the letter: thus between verses 274 and 294 we learn that γράφειν is used as a synonym of χαράσσειν, *to incise, to carve, to engrave*, and that χαράσσειν means *to cut right off*, *to hew*, in verse 246 of the "Descriptio Ambonis." And last, but not least, we find the poet, in his description of the *Opus Sectile* of the gallery (composed, as we know, of inlaid pieces of marble), connecting the verb ἔγραψε with its subject λαοτόρος, *sculptor*, whose office was certainly not to paint, but to bore, and to cut, stones with a chisel.

‡ *Cantacuzenus*, ed. Bonn, pp. 196-202.

§ It is not certain that the Ambo of St. Sophia differed very much from the great pulpit of St. Mark's, Venice, which also has two sets of colonnades. It must have been, however, much larger, as holding many people at the coronation ceremony.

THE EASTERN BAY OF THE GREAT CHURCH,
ST. SOPHIA, CONSTANTINOPLE.

Probable View of the Choir and of the Sanctuary in the tenth century.

this Plate, so as not to interfere with the view of the Holy Screen beyond. Then we have the enclosure of the Soleas, on each side of which were the Singers' Stalls, headed by the Imperial Throne and its two lions to the right. The stalls of the Choir are shown to continue parallel to the axis, and not curving into the cylindrical walls of the conchs, as in that case the voice of the singers would be inaudible from some points of the nave. Huge candlesticks would stand in front of the Iconostasis, while the Holy Door must have been crowned by the two-headed Greek Eagle.

Lastly, beyond the twelve columns of the Iconostasis, the worshipper would see towering the Ciborium (baldachin) of the Altar, surmounted by a cross resting on a globe, symbol of the expansion of Christianity over the world's surface.*

We learn from the Silentiary that originally the whole extent of the first floor level was reserved to the women. Gradually, however, the increasing numbers, offices, and requirements of the clergy, caused them to invade the galleries, and to permanently establish themselves in the southern and south-eastern divisions of the right aisle. A fine marble screen, still extant, separated the central hall, or *Great Secretum*, from the rest of the Catechumena, while the dome immediately to the east represented the Pentecost in mosaic—a fitting subject to the ecclesiastical councils and to the Synod of 869, held in this part of the church.

The western section of the Gyneceum was known by the name of *Catechumena of the Narthex*, as extending above the vestibule. We know that veils used to stand here, screening the women from the nave below, and the iron ties of the bolts, from which the veils were suspended, have been seen in position by the writer in 1902, both on the piers, as well as on the twin columns over the Royal Gates.

The structure is full of symbolism, and the reasons for the presence of lily, vine leaves, fishes, dolphins,† etc., in the decoration are obvious. So also is the groupment, or division, in three of the windows. Numbers to whom preference was given seem to have been 2, 3, 4, 6, 7, 8, 9, 12, 16, 24, 32, 36, 40, 48, 60, 72, 96, 100, 120, 160, 180, 220, 240, 260, and 300. The mystic number 40 is repeated many times:

(1) In the diameter, in Byzantine feet, of the cylindrical opening of the eastern apse;

(2) In the diameter, in feet, of the four exedras;

(3) In the length, from column to column, of the corner divisions of the aisles and gallery;

(4) In the height of the first cornice;

(5) In the mean height of the vaulting in the aisles and Narthex;

(6) In the total height of the four domes in the angles of the first floor;

(7) In the number of columns of the floor;

(8) In the number of columns of the gallery, towards the nave; and

(9) In the number of ribs, piers and windows of the dome.

According to the writer's own measurements, the side of the square area covered by the pendentives and by the dome is 102 English feet and 2·4 inches, or 31·15 metres. But this represented 100 Byzantine feet. Hence one Byzantine foot is equal to 1·0220 English, or 0·3115 metres.

* The true mosaic decoration of the eastern semi-dome is not known. Plate II. gives its present decoration by Fossati, while the "Mystic Lamb," shown in Plate I., is merely intended to symbolize our agnosticism on the subject.

† The dolphins and trident of Neptune were an old emblem of Byzantium.

The vaulting of the church rests on the piers and outer walls, as well as on 104 columns, but of which only 96 are round. Considering that this quantity is the multiple of so many numbers as 2, 3, 4, 6, 8, 12, 16, 24, 32 and 48—all favourite numbers—its choice was certainly premeditated, and not the result of chance.

Fig. 8 shows a typical mediaeval Greek capital with the monogram of Justinian, carved out of the marble, and repeated on the brass ring. Probably, as remembrances of paganism, ancient Greek capitals were rejected.

The great verd-antique shafts, separating the nave from the aisles, are not all equally strong. Four of them have a diameter of $42\frac{1}{2}$ inches, while the other four measure only $38\frac{1}{4}$. The thin columns have been erected in the centre of the sides, the stronger ones near the piers. Still, the first impression is that the colonnades are uniform; the extreme

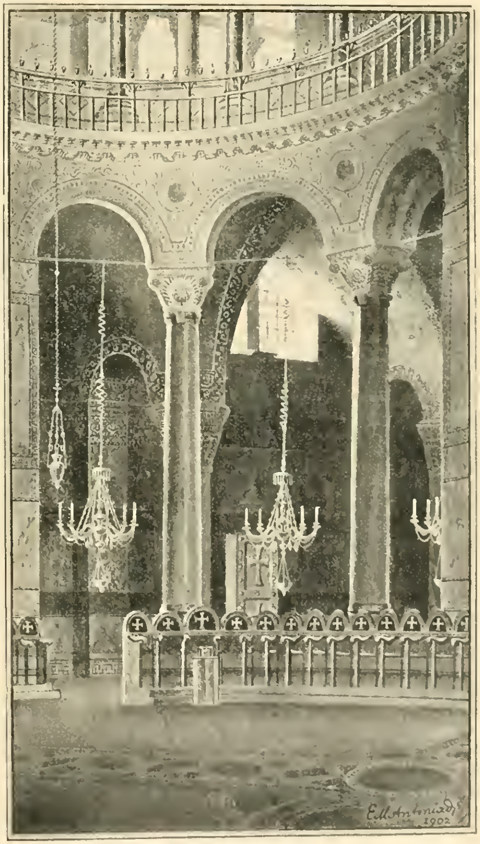


Fig. 9. A View of the south-eastern Exedra, and of the Great Porphyry Columns, showing the Singers' Stalls and Metatorion in the background, at the time of the Emperor Constantine Porphyrogenitus.

shafts seeming reduced in thickness through the dwarfing vicinity of the piers.

The treatment of the supports in the four exedras (Fig. 9) required much more delicacy, inasmuch as it was deemed desirable to render the importance of the conchs

subservient to that of the great central colonnades under the dome; and yet it would have been dangerous to tamper with the solidity of the shafts, since it is on the exedras that devolves a considerable part of the thrust exerted by the great arches, pendentives and semi-domes, and, indirectly therefore, of the dome itself. A reduction in height and diameter of the exedra columns secured their subordination to the grand colonnades; while the loss of solidity thus incurred was in some measure atoned for by the judicious choice of carmine Theban porphyry—the strongest stone used in the church—as an effective check to the tremendous weight of the vaulting above.*

If we revert to our plan, in the March number of Knowledge, we shall find that the abutments of the dome are fairly satisfactory on all sides; although ill calculated to remain unbuttressed for many centuries in a soil visited by frequent and violent earthquakes. But the abutments of the lateral walls will be judged at once quite inadequate to the wide spans of the aisles and galleries; a defect further aggravated in the angles by the additional thrust of the exedras. It was, therefore, impossible for Justinian's church to have stood long unbuttressed Trouble must have very soon made itself felt, first in the angles, then in the midst of the north and south sides as well as to the east, right and left of the Sanctuary, and lastly, after several centuries, in the very abutments of the semi-domes and of the dome.† Historical evidence confirms these deductions to the letter. We find, accordingly, the south porch, and of course the lateral ascents, in position as far back as the reign of Theophilus, 275 years only after the second dedication, whereas the sturdier piers of the nave opposed, unbuttressed, a gallant resistance to the earthquakes of 754 years.

But, in framing these criticisms, we should not be apt to forget that, if the great architect, to whom we owe that marvellous conception, showed himself fallible, in underestimating the effects of thrust, he was necessarily lacking that experience which we acquire to-day by a mere glance thrown on the buildings of his time, now fourteen centuries old. Domed structures in the beginning of the sixth century were comparatively new, few, and unimportant. Nor could the vast, but grovelling, cupola of the Roman Pantheon yield any object lesson in the propping of an aerial dome at the height of 130 feet.

A word or two on the solidity of St. Sophia in the present day, and we will have finished with these disjointed fragments. The part of the church which has suffered most is the south angle, where the column of the gallery has been thrust nearly 7° out of the vertical (Fig. 10). But a strong double buttress, rendered immovable by the weight of the minaret erected by Mohammed II., checks any further inclination of the column. The arches to north and south are smaller by 28 feet than those to east and west, and, having proper support in the plan, are fairly strong. As in the past, danger is to be looked for in the great open arches to east and west. Inasmuch as the four main piers are well buttressed from without, their failing in a direction parallel to the lesser axis is an impossibility. The age of the eastern arch is 540 years, and this part of the vaulting seems to be in excellent state, as the stone masses erected by Andronicus Paleologos consolidate all the east front. But the western arch is 920 years old, and notwithstanding its buttressing, together with the great niche, by an additional thickness, has been deformed by the thrust of the cupola, the result being an exaggerated concavity of the semi-dome. Moreover, this arch has suffered much during the earthquake of 1894, and its last repair has necessitated the removal of the fine

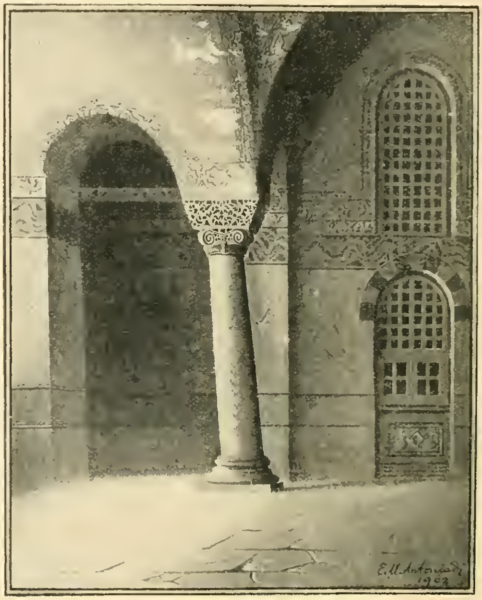


Fig. 10.—Dangerously-inclined Column in the right-hand Catechumena, or first floor level.

mosaic eikon of the Virgin at the crown. And thus it is that the possibility of an eventual rupture of equilibrium along the major axis, to the west, is the chief cloud in the solidity of the edifice. Still, the danger is certainly far from imminent, so that there are excellent reasons to hope that the venerable dome of the Eternal Wisdom, hallowed by the universal verdict of nations, and reverenced by the ravages of time, will continue inciting, for long centuries to come, the pious fondness and genuine admiration of mankind.

* Probably these shafts were not long enough, so that they may have facilitated, or even decided, the subordination in question. In his work on *Aya Sofia, Constantinople*, London, 1852, p. 2, Fossati says that during the reparations conducted by him from 1847 to 1849, he brought back to the vertical thirteen columns of the Gynecceum which had been pushed out by the thrust of the lateral arches. Great credit is, therefore, due to Fossati for this architectural triumph, by which he has so powerfully contributed to the consolidation of the church.

† In his restoration of the exterior for 1300 (Fig. 3) the writer has eliminated part of the buttressing of the aisles, with a view to showing as clearly as possible the original design of the church.

MODERN COSMOGONIES.

By Agnes M. Clerke.

II.—CRITICISMS OF THE NEBULAR HYPOTHESIS.

Laplace's theory was a perfectly definite conception. In this lay its distinctive merit; in this also its special susceptibility to attack. Here was no question of condensations round nuclei arising at discretion amid the large possibilities of boundless elemental confusion; but of an orderly succession of occurrences, rendered inevitable by the steady operation of mechanical laws, and harmonising, in their outcome, with the array of ascertained phenomena visible in the planetary system. These, accordingly, ceased

to be regarded as arbitrary or casual; they became linked together, in the present, and with the past, as joint products of one grand scheme of development. The mode of origin of the bodies exhibiting them accounted, its inventor claimed to have shown, simply and entirely for them all; and at least the fundamental propositions laid down by him could not be gainsaid. Clearly, the unanimity of planetary movements is no result of chance; it represents, quite obviously, a survival of the general swirl of an inchoate mass, occupying primitively the whole recognised sphere of solar influence. Ambiguities set in only when details come to be considered. The engendering nebula devised by Laplace was provided with a vast endowment of heat, and a slow movement of rotation; hence cooling, contraction, and acceleration advanced *pari passu*, the last as a consequence of the dynamical law by which the algebraic sum of the areas described by any number of bodies round a given axis, multiplied by their several masses and projected upon a single plane, remains constant to the end of time. In other words, the moment of momentum of a congeries of particles can neither increase nor diminish, unless through the action of an external force.

The nebula then quickened its pace until a stage was reached at which centrifugal speed could no longer be controlled by gravity; separation became inevitable, and an equatorial ring was abandoned, which thenceforward revolved on its own account in the period conformed to by the undivided mass at the epoch of its secession. This was the first of many subsequent crises of instability, each eventuating in the detachment of a nebulous ring These rings, however, were regarded as merely transitional forms. They survived, just for illustrative purposes, in the Saturnian system; elsewhere they broke up into fragments which ultimately coalesced into globes; and the globes were embryo planets. There was indeed a hitch in the line of argument which did not escape the acumen of the French geometer. The direction of the axial movement imparted to the members of the solar family depended essentially upon the relative velocities of the portions of matter brought together for their construction. If the inner sections of the self-shaping mass moved faster than the outer, the resulting rotation should have been retrograde; if slower, direct rotation would have ensued. Now, in a ring like that of Saturn, composed of discrete particles, linear speed decreases continuously outward, each of its minutest constituents obeying independently Kepler's law of periods and distances. Such a formation would therefore have been unfit for the purpose in view, and Laplace accordingly substituted an annulus endowed with a considerable amount of cohesion, and capable of rotating, like a solid, in a single period. It is true that such unanimity of movement was incompatible with the other postulated conditions; but the anomaly escaped notice for above half a century.

The prescribed genetic process, at any rate, whether workable or not, was a strictly regulated one; its steps were marked with characteristic precision. Yet by this very determinateness it gave hostages to the future. It challenged the application of tests which designs more vaguely sketched might have evaded. The primary criterion of its truth was the prevalence of concordant motion throughout the solar domain. The possibility of counter-currents was formally excluded. Hence the discovery of the retrograde systems of Uranus and Neptune flatly contravened its pretensions to unconditional acceptance. With less evidence, but equal certainty, Laplace's hypothesis involves the consequence that each planet circulates in the identical time occupied by the rotation of the undivided nebula just before instability toppled over into separation. Each of the planetary periods should accordingly bear a certain ratio, prescribed by inexorable mechanical law, to the actual period of the sun's rotation. In point of fact, however, the periods in question are much shorter than comports with the necessity for the conservation from age to age of the system's moment of momentum. The discrepancy was adverted to forty-two years ago by M. Babinet.* He showed, in March, 1861, that the axial movement of the solar mass, when distended to fill the sphere of Neptune, should have been, by the law of areas, so excessively slow that more than 27,000 centuries would have been needed for the completion of a single rotation; while the period, even when the shrinking nebula had come to be bounded by the terrestrial orbit, must still have been protracted to 3181 years. Under these circumstances, centrifugal force would never have over-balanced central attraction; no rings could have separated, and no planets could have been formed.

Quite recently, Mr. F. R. Moulton of Chicago† has reconsidered the subject in the course of a careful and candid discussion of the difficulties besetting the Nebular Cosmogony as viewed from the standpoint of modern science, and he comes to essentially the same conclusion. His calculations, though founded on data expressly chosen so as to give the classic theory the benefit of every doubt, made it perfectly clear that the moment of momentum of the embryo planetary system should have exceeded its present value no less than 213 times if, when it extended to the distance of Neptune, it rotated in what is now the period of Neptune. But moment of momentum is a constant The lapse of millions of years makes no difference to it; it can neither have increased nor diminished since the sky was first flecked with the "breath-stain" that was appointed to condense into our sun, which, at every stage of its subsequent evolution, must, in this respect at least, have maintained immutability. On the other hand, this being so, its primeval wheeling motion would have been much too leisurely to permit the occurrence of accesses of instability. Gravity would have steadily kept its supremacy over the forces tending to disruption until the nebula had contracted to less than the compass of the Mercurian sphere; and its overthrow at that epoch would have been too late for the origination of any of the sister-orbs of the earth. These results, it is true, depend in part upon the mode of variation in density ascribed to the progressively shrinking nebula; but the law adopted by Mr. Moulton has a consensus of authorities in its favour. Nor could its deviation from exactitude—if it be inexact—possibly suffice to account for the enormous discrepancies brought to light by its aid.

The Nebular Hypothesis stipulates further that satellites must revolve more slowly than their primaries rotate. The reason is patent. In the periodic time of a detached body the rate of gyration of the original mass is, if the theory be valid, perpetuated. Subsequent contraction tends to quicken, and very greatly to quicken, the rotation of the planet, while the period of the satellite survives unaltered as a standing record of what the joint period was. This relation may indeed be modified by the effects of tidal friction; but it is more than doubtful whether it can ever be reversed. It is, then, a characteristic feature of the mode of evolution described by Laplace that no month—so to speak—can be shorter than the corresponding day. And the rule is conformed to in nearly every part of the solar system. Nevertheless, two flagrant violations of it have lately obtruded themselves upon notice, and can scarcely be explained away by supplementary hypotheses.

* *Comptes Rendus*, t. LII., p. 481.

† *Astrophysical Journal*, Vol. XI., p. 103.

The first ascertained anomaly of the kind was met with in the swift circulation of Phobos, the inner satellite of Mars, which completes three revolutions, and enters upon a fourth, while the planet attended by it wheels once on its axis. The fact is most perplexing; and the confident persuasion that solar tidal friction would avail to remove the difficulty has not proved well grounded. Solar tidal friction, it may be remarked, acts as an external force upon subordinate systems submitted to its influence. Within their precincts, moment of momentum may be destroyed by it; and it was hence a feasible supposition that the rotation of Mars had, in the course of ages, greatly slackened through the retarding effect of sun-raised tides. But the agency was demonstrably inadequate to the task assigned to it. The reduction of the rotational moment of Mars to about one twenty-fifth its primitive amount* would have brought other consequences in its train, at least one of which did clearly not ensue. At an early stage of the process, Phobos should have been re-engulfed in the parent body.† For the pull of the small tidal wave raised by it on the surface of that body would have been backward from the instant that the balance of periods became inclined, through solar compulsion, in a direction contrary to that it would naturally have taken; and the loss of velocity must have entailed its descent, along a spiral path, towards an inevitable doom. The continued existence, then, of the little satellite closes this way of escape from the difficulty raised by the shortness of its period. M. Wolf had recourse to a different explanatory subterfuge.‡ He believed that Phobos might have owed its origin to one of Roche's "elliptic sheddings" of nebulous matter dropped downward from near the polar regions of the distended Martian spheroid, and rotating, owing to its low rate of linear speed, in the immediate vicinity of the cooling planet. The explanation, though ingenious, is too recondite and evasive of mental grip to be satisfactory.

The Saturnian system exhibits a case of the same kind, but still more perplexing to speculative prepossessions. Saturn's ring system has always appealed to thinkers as a striking object-lesson in nebular development. It forcibly arrested Kant's attention, and he sketched its birth-history on lines anticipatory of those adopted by Laplace for the solar system in its entirety. Laplace himself regarded the formation as the one surviving relic of the annular stage of planet-building—as a witness from the dim past to a condition of things elsewhere transitory. Yet the witness has turned king's evidence, and betrayed the whole situation. The innermost Saturnian ring has a period far too short to be compatible with the requirements of theory. For its meteoric constituents, which are known to revolve as independent units, complete their circuits in between five and six hours, while the planet needs just $10\frac{1}{2}$ for its axial rotation. Moreover, tidal friction is here far less available than on Mars; yet no other retarding agency has been invented. The deadlock appears final and hopeless.

An objection quite as formidable, and even more fundamental, was raised by Kirkwood in 1869. The nebulous material of the uncondensed sun must have been, at the outset, of the last degree of tenuity. Atmospheric air is, by comparison, a dense and massive substance. Yet no reasonable person could ascribe to aerial matter the least power of resisting strain. We know perfectly that a rotating globe of air, and, *à fortiori*, a globe of matter thousands of times less compact than air, would unintermittently disintegrate at the surface with the progress of acceleration. The disturbance and restoration of equilibrium would be virtually simultaneous. There could be no accumulation of internal stress, and consequently no distinctly separated epochs of instability. At the first solicitation, at the first instant that centrifugal velocity gained the upper hand over gravity, nebulous wisps would have become detached; and their detachment would have gone on without pause. Space would have been strewn with the *débris* of the condensing nebula; and there should have resulted a vast cloud of cosmic dust, not a majestic array of revolving spheres.

Moreover, even if the nebulous material had possessed the fabulous cohesion indispensable for its division into voluminous rings with wide intervening empty gaps, their ultimate agglomeration into planetary globes would never have been effectually accomplished. Kirkwood long ago questioned the feasibility of the process; Mr. Moulton has gone far towards demonstrating that it must have had an abortive outcome.

Another grave objection to Laplace's scheme is founded on the marked deviations visible in the solar system from conformity to a fundamental plane of motion. Apart from unexplained modifying influences, all the planets should circulate along the level of the sun's equator, and rotate on axes perpendicular to it. How far this is from being realised in nature we have only to look around us to perceive. We owe the changes of our seasons to the tilted fashion of the earth's spinning. Yet it is by no means easy to understand how the pole of its equator comes to be situated in the Tail of Ursa Minor, while the pole of the ecliptic is involved in the folds of Draco. They should have coincided if the simple prescription of the Nebular Hypothesis had been followed in the making and modelling of the planets. Nor are the terrestrial arrangements exceptional. The Saturnian equator and the Saturnian rings have a still higher inclination; while, in the systems of Uranus and Neptune—since we may thus interpret their retrogade revolutions—the angle exceeds the limit of a quadrant. These and other similar discrepancies prove the solar mechanism to have originated by a more complex method than that imagined by Laplace; and an hypothesis which invokes the aid of a multitude of auxiliary devices for its extrication from accumulating embarrassments falls thereby under the suspicion of not being worth the trouble of extricating. It forfeits, at any rate, all claim to commendation for directness and simplicity.

The Cosmogony turned out at Paris has thus proved vulnerable on a number of points; but all the blows aimed at it have not told with such deadly effect as those just referred to. Some have fallen harmlessly, or glanced aside. One hostile argument in particular, which for a time seemed irresistible, has been completely overthrown by the logic of facts, and deserves mention only as a historical curiosity. Towards the middle of the nineteenth century, the progress of sidereal astronomy seemed to take the direction of showing all nebulæ indiscriminately to be of stellar composition. With Lord Rosse's great reflectors, a good many such objects were genuinely, and some besides were deceptively, resolved into stars, the illusory effects being confirmed by Bond's observations with the deservedly celebrated fifteen-inch refractor then recently built by Merz for Harvard College. Hence the rash inference was drawn that resolution was wholly a question of optical power, and that no real distinction existed between the stellar and the nebular realms. Herschel's "shining fluid" assumed a mythical air; "island-universes" came into popular vogue; and all but a few careful thinkers held nebulæ and clusters to be differentiated merely by degrees of remoteness. But if space contained only full-grown stars, and no stars in the making—no star-spawn, no star-protoplasm—then the imagined

* Moulton, *Astrophysical Journal*, Vol. XI., p. 110.

† Nolan, *Nature*, Vol. XXXIV., p. 287.

‡ *Bull. Astr.*, t. II., p. 223.

evolutionary history of our system was left in the air, destitute of even the most fragile prop of observed fact.

From this precarious position it was rescued, partly by the cogent reasonings of Whewell and Herbert Spencer, finally and triumphantly by Sir William Huggins's spectroscopic discovery of the cosmic gas "nebulium." Since August, 1864, there has been no possibility of denying that the heavens contain ample stores of just the kind of material Laplace wanted, though whether it played just the part he assigned to it, in the manner that he supposed, is a question to be answered with profound and growing reserve.

An objection of late urged against the Nebular Theory, from the standpoint of the kinetic doctrine of gaseous constitution, is of much speculative interest. From a gaseous nebula equal in mass to the sun and planets, and distended sufficiently to fill the orbit of Neptune, there should have been, if the prevalent opinion be correct, a rapid leakage into space of its lighter ingredients. Of hydrogen and helium, we are told, it should infallibly have become depleted; yet there is no lack of either in the sun of the twentieth century. Their retention, it must be admitted, is, on the hypothetical conditions, difficult to account for. The "critical velocity" at the limiting surface of the supposed nebula would have been 4·8 miles a second. This is, in fact, at the distance of Neptune, parabolic speed. The planet itself, if it could attain to it, would break the bonds that bind it to the sun, and seek its fortunes under some different allegiance. Similarly, any particle of the primitive nebula thus accelerated should have become an irreclaimable vagrant. Now the velocity of hydrogen-molecules at the zero of Centigrade is, in the mean, about $1\frac{1}{6}$ miles a second, but attains, in the extreme, to above seven miles. Hydrogen could not then have been permanently retained by the solar nebula; and the escape of helium would have more slowly ensued. Yet these results, though seemingly inevitable, did not, in actual fact, come to pass; either because the generating body was differently constituted from what has been supposed, or because countervailing influences were brought to bear. It is, for instance, amply possible that the dynamical condition of gases may be essentially modified by rarefaction carried to a degree transcending the range of experimental investigation. The progress of science affords many warnings against trusting implicitly to the rule of continuity. Curves of change seldom preserve indefinitely a uniform character. Their unexplored sections may include quite unlooked-for peculiarities of flexure; and the possibility seriously undermines confidence in inferences depending upon "extrapolation." The presence of hydrogen and helium in our system cannot, then, be ranked among facts incontestably contradictory of the Nebular Hypothesis.

The concerted advance of mathematical astronomy during the eighteenth century was effected with the confident serenity of irresistible power. One after another, the obstacles barring its path went down before repeated and skilful onslaughts, the unbroken succession of which lends a certain exultant sameness to the story of the heroic age of analysis. The *Mécanique Céleste* attested "victory all along the line." There were no more worlds to conquer that Laplace knew of; the reign of gravitational law was firmly established throughout the solar dominions; menaced revolts had been appeased; anomalies removed; no extant observations any longer impaired the perfect harmony between what was and what had been anticipated. Nature for the moment submitted readily to the trammels put upon her by human thought; her intricacies no longer seemed to defy unravelment; her modes of procedure looked straightforward and intelligible. As they were judged to be in the present, so they might be presumed to have been in the past; and the temptation was irresistible to adventure backward speculation, inferring initial conditions from the elaborated product laid open to scrutiny.

It was an epoch of peremptory renewals. The formula of equality promised to regenerate society; a political panacea had been found by the creation of a Republic "one and indivisible"; and the success of the guillotine in securing its supremacy was almost outdone by the triumphs of the calculus in vindicating the unimpeded sway of gravitation.

Humanity had made a fresh start; science should do likewise. The sanguine spirit of a rejuvenated world animated all forms of human endeavour. It has long since evaporated. The buoyant hopes of a century back have been crushed; the future of civilization looks dim; the future of knowledge is compromised by its uncertainty. But we, at any rate, no longer delude ourselves with the idea that he who runs may read the secrets of the universe; we have learned by convincing experience how much, and how variously, "the subtlety of nature transcends the subtlety of sense and intellect"; we are vividly aware that there is no single and simple recipe for the "cosmification" of chaos.

That devised by Laplace has ceased to be satisfactory. Its simplicity, at first sight so seductive, leaves it at a disadvantage compared with the intricacy of the effects it was designed to elicit. The relations claiming explanation have multiplied with the progress of research. Those of the dynamical order were alone attended to by the geometers of the eighteenth century, and even they have grown recalcitrant; while those of a physical and chemical kind have proved wholly unmanageable. It has indeed become abundantly clear that the series of operations described by Laplace could scarcely, under the most favourable circumstances, have been accomplished, and in a thin nebulous medium would have been entirely impossible. The Nebular Cosmogony has not then stood "Foursquare to all the winds that blew."

Its towers and battlements have crumbled before the storms of adverse criticism. It survives only as a wreck, its distinctive features obliterated, although with the old flag still flying on the keep. In the next chapter we shall attempt a survey of the works set on foot for its reconstruction.

Letters.

[The Editors do not hold themselves responsible for the opinions or statements of correspondents.]

MAN'S PLACE IN THE UNIVERSE.

TO THE EDITORS OF KNOWLEDGE.

Sirs,—As I do not wish your readers to suppose that I have altered the words of an author whom I quote in order to make them agree more closely with my own opinions, will you permit me to state, in reply to Mr. Maunder's criticism of my article in the *Fortnightly Review*, that when that article was sent to press I had not seen Prof. Newcomb's book on "The Stars"; but I quoted from his "Chapters on the Stars," which appeared in *The Popular Science Monthly*. The quotation beginning "If we should blot out," is verbatim, as at page 323 of that periodical for January, 1901, except that I have, inadvertently, substituted "Milky Way" for "galaxy."

A writer in the *Daily News* of March 31st has so well answered Mr. Maunder's criticisms that it is unnecessary for me to refer to them here. I am, however, indebted both to Mr. Maunder and to Prof. H. H. Turner, who has criticised my article in this month's *Fortnightly*, because,

although I consider their objections to be rather weak, and with one exception not much to the point, they are yet of great use to me, as showing me where my argument needs strengthening or where I am likely to be misunderstood.

In a volume I am now preparing I hope to be able to present my views in a more complete and more convincing manner.

Broadstone, Dorset, April 8th, 1903. Alfred R. Wallace.

TO THE EDITORS OF KNOWLEDGE.

Sirs,—Dr. A. R. Wallace's biological investigations have been elevated and illuminated, throughout their long course, by his strong appreciation of the incomparable moral dignity of Man. And this, too, is the inspiring thought of his recent article in the *Fortnightly Review.* It rises beyond discussion; welcome assent is the only fit attitude of mind towards it. But the profound significance of human life would be no whit impaired by assigning to the scene of its expansion an eccentric position in the universe; and a central position, as Mr. Maunder has shown in Knowledge, and Prof. Turner in the *Fortnightly Review*, can belong only momentarily to a moving body. Nor can it reasonably be supposed that the conditions of vitality deteriorate with remoteness from the centre. In the actual throng of the Milky Way, indeed, a peopled planet might be exposed to perils from "furious driving," or subtler obstructions to traffic. Within its ambit, however, there is "room and verge enough" for the unimpeded travelling of many millions of globes, freighted though they may be with superhuman destinies.

But has the universe a centre? In other words, is it of limited dimensions? Dr. Wallace avers that it is. His arguments are, nevertheless, contravened by the high astronomical authorities just referred to. The all-pervading illumination of the sky-ground, which should attest the shining of infinitely numerous suns, would be prevented, they agree in considering, by the intercepting action of an *equally infinite* number of dark bodies. These, however, cannot be supposed to screen off gravitational influences; they should, on the contrary, reinforce them. Hence, every body in space would be acted on by infinite forces, soliciting it to move in every direction at one and the same time. Cosmical paralysis would result; the "constellated suns" would stand stock still; unless we make the hazardous assumption that a finite attraction, super-added to an infinite sum of attractions, might avail to determine velocity. That is to say, neighbouring stars might exert effective pulls upon each other irrespectively of the equilibrating pull of a measureless universe.

There is, however, little profit in dwelling upon this baffling aspect of the question; clearer evidence is before our eyes. Everywhere in the heavens structural relations are manifest. Architectural design is traceable in them; they have parts fitted in together to form a vast yet limited whole. The Galaxy has shape and boundaries, and we have no assured knowledge of anything lying outside those boundaries. It seems, then, a gratuitous exercise of the imagination to conjure up abysses stored with stars, energetic and effete, one set cutting off the radiations of the other.

Undeniably, Dr. Wallace's contention that our earth is unique as being the abode of intelligent life corresponds, in a measure, with the recent trend of astronomical research. The conditions indispensable to organic existence which he has admirably defined are perceived, more and more plainly, not to be present on any of our sister-planets with the possible exception of Mars. Moreover, a large proportion of the stars have been ascertained to form systems unfavourably circumstanced for the accommodation of globes approaching the terrestrial model. Boundless variety, it is true, prevails throughout the sidereal scheme; and this variety may only afford scope for the display of the contriving power of Infinite Wisdom in smoothing away apparent obstacles to life, and so vitalising the seeming deserts of the universe.

Agnes M. Clerke.

TO THE EDITORS OF KNOWLEDGE.

Sirs,—With reference to Dr. Wallace's article on this subject in the *Fortnightly Review* for March, 1903, I should like to make a few remarks.

As it is at present impossible to fix the exact limits of the visible universe we cannot determine where its centre may lie, and although the sun and solar system *apparently* lie near the centre of the Milky Way, it does not follow that we are really at or near that centre. Indeed, there is evidence to show that we are perceptibly nearer to one side of the Milky Way than to the opposite side. Sir John Herschel was of opinion that the southern portion of the Milky Way near the Southern Cross is nearer to us than the northern part. Professor Newcomb considers that we are probably nearer to the boundary of the visible universe which lies in the direction of Sagittarius and Scorpio, and he thinks that we may possibly be so much nearer this particular region that we may soon be able to detect proper motions among the fainter stars in this direction.

Considering the sun's motion through space as rectilinear, I pointed out ten years ago ("The Visible Universe," p. 197) that at some period back in geological times the sun was probably among the stars of the Milky Way. The solar "apex," or point towards which the sun is moving, is, according to Prof. Kapteyn, in about R.A. 273°·6, North Declination 29°·5, and he thinks that "the most probable value that can at present be adopted" for the sun's velocity is 18·45 kilometres, or 11·46 miles a second. With this velocity, the sun's annual motion would be about 360 millions of miles (or nearly four times the radius of the earth's orbit). Hence the distance traversed in, say, 200,000 years would be 72 billions of miles. As the distance of Sirius from the sun may be taken as 50 billions of miles (parallax 0″·37), the solar motion carried back would place the sun far beyond the distance of Sirius 200,000 years ago. If we go back in geological times, say 5 millions of years, we find the sun at a distance of 1800 billions of miles from its present position in space. This would represent the distance of a star with a parallax of about 0″·01, or about 326 years' journey for light. Removed to this distance the sun would be reduced in brightness to a star of the 10th magnitude. It follows, therefore, that if the sun is moving in a straight line it must have been close to the position of 10th magnitude stars (if of the same size and brightness) some 5 millions of years ago. Going further back in geological time we should find the sun among the stars of the Milky Way. From the apparent connection of bright and faint stars in the Galaxy, Easton thinks that the faint stars of the Milky Way are at a distance which does not greatly exceed that of stars of the 9th and 10th magnitude (*Astrophysical Journal*, March, 1895).

It is of course possible, and indeed probable, that the sun is not moving in a straight line, but in some gigantic orbit round a centre of force. Recent researches seem to show that the centre of the Milky Way probably lies in a direction south of Cassiopeia's Chair, and a little south of the Milky Way (about R.A. 24h.), the sun and solar system lying to the south of the galactic centre, and a little to the

north of the plane of the Milky Way. Now the "apex" of the solar motion lies roughly 90° from this position, and judging from the position of the apex found by Sir William Herschel, Argelander and Airy (about 17h. 30m.), and that indicated by recent researches (about 18h. 30m.), there may perhaps be a shift of the apex towards the centre of the Milky Way, which should be the case if the sun were revolving round a centre. This supposed "shift" may of course be more apparent than real, and may, perhaps, be partly or altogether due to errors of calculation. The various positions, however, assigned to the apex show a tendency at least to shift towards the supposed centre of the Milky Way. However this may be, it seems not improbable that the sun may be revolving round the centre of gravity of the Milky Way, which may also be the centre of gravity of the whole system of stars composing our visible universe. But if this be so, the sun is probably at a great distance from the centre. For its measured velocity is considerable, and in a system of stars, like a globular cluster, those near the boundary would have a greater velocity than those near the centre, the law of force in such a system varying *directly* as the distance from the centre. J. E. Gore.

Dublin, April 14th.

TO THE EDITORS OF KNOWLEDGE.

Sirs,—Some further remarks on the question recently mooted between Dr. Wallace, on the one side, and Mr. Maunder and Dr. Turner, on the other, may be of interest to the readers of Knowledge. First, all the astronomical arguments in favour of a finite universe seem to me to turn on the assumption that the ether is infinite Admittedly it is only by the light of very distant objects that we learn their existence; and for the transmission of this light, ether is necessary. Our knowledge is, therefore, confined within the limits of the ether, whether it be finite or infinite. But how can we draw any conclusion as to the finiteness or infiniteness of the universe if all that we can know of it is limited to the finite sphere of the ether? With an infinite and perfectly transparent ether, a limited number of shining bodies would be suggestive of a limited universe of matter; but if the ether itself be finite, we would, in drawing this conclusion, act like an islander who imagined that his island was the only bit of solid land in creation, because, when looking round on every side, he could see nothing but water. His universe would be limited by the curvature of the water as ours (on this assumption) is by the finiteness of the ether. But Dr. Wallace fails to see this. He speaks of bodies wandering outside the limits of the ether, but assumes that they would be cold and dead, &c. Why? If ether is necessary to convey heat to them, it is equally necessary to convey it away. They would, therefore, simply retain their heat without change. That they would be dark I admit, but light is not necessary to animal life. Then, if *our* ether be finite—if it be like a vast attenuated nebula—why may there not be other great nebulæ of ether in external space, some of them, perhaps, much larger and better supplied with stars than our own? A finite ether practically excludes us from knowing anything beyond its limits, and for that very reason it allows scope for all kinds of conjecture as to what is really beyond them. Dr. Wallace does not suppose it to be a vacuum. There are bodies in it which once belonged to our universe; and why should there not also be bodies in it that never formed part of our universe—never entered our ether? There are, at all events, no grounds for dogmatising on this subject. (But I do not think any observation has shown such appearances and disappearances of stars as would arise from their entering or leaving the ether.)

We are, according to Dr. Wallace, in the centre of the universe. He infers this from our position in relation to the visible stars. I need hardly say that when our knowledge of the visible stars is carried further, our present ideas as to their distribution may be largely modified, and even as it is I doubt if any astronomer could go within 1000 light-years (if I am to use that ill-selected unit) of the centre of the star-system as at present known. But so far as we know, while heat, light, and some other influences are dependent on the ether, gravitation is not, and whatever the distance may be its transmission is instantaneous. Hence if there are bodies outside of the ether, as Dr. Wallace supposes, these bodies are as influential in determining the centre of the universe as the bodies which are situated within the limits of the ether. No doubt the distance of these outlying bodies must be very great, but their number and mass may also be very great, and some of them may not be more distant than some of those within the ether but near its confines. A finite material world in an infinite ether is a hypothesis which finds some support in the facts of astronomy. A finite ether with matter (perhaps infinite) beyond it, is also to a certain extent a feasible hypothesis; but a finite ether and a finite material world having distinct and independent limits seems to me to be the worst hypothesis of the three, and is, moreover, one that does not assist us in fixing the centre of this finite universe of matter.

I therefore reject the astronomical basis of Dr. Wallace's theory, leaving it to others to deal with the conditions of animal life and mental development. I confess, however, that I have sufficient faith in the principle of evolution to think that man might accommodate himself to the conditions of life on almost any of the planets, provided that the change were sufficiently gradual, and a sufficient time were allowed to elapse. But some arguments used by Mr. Maunder and Prof. Turner seem to me also unsatisfactory. The first of these is the argument drawn from the number of dark bodies in space in answer to the proofs of finiteness deduced from the faintness of the general illumination of the sky. What would be the consequence if the dark bodies were on the average as numerous and as large as the bright ones, while the sun were adopted as an average specimen of the latter? Simply that the average illumination of the entire sky would be half that of the sun. The dark bodies would be as often behind the bright ones as before them. Now compare this with the fact. The highest estimate that I have seen of the total light of the full moon is $\frac{1}{300000}$ of that of the sun, the discs of the two bodies being about equal. Suppose that the dark bodies were 150,000 times as numerous as the bright ones, instead of being equal in number. Then the whole sky ought to be as bright as the illuminated portion of the moon. Everyone knows that this is not so. But it is said that the stars, though infinite, may only extend to infinity in particular directions, *e.g.*, in that of the Galaxy. Be it so. Where in the very brightest portion of the Galaxy will we find a portion equal in angular magnitude to the moon which affords us the same quantity of light? In the very brightest spot, the light probably does not amount to $\frac{1}{100}$ part of that of the moon (when full), thus raising the proportion to fifteen millions to one. Dark bodies may explain why the sky-light is not infinite—which in fact it could not be even if all bodies were bright, and their number infinite—but the extremely small amount of sky-light which actually exists is a startling fact, and one difficult to reconcile with the theory of an infinite material universe.

Again, I think too much stress has been laid by Dr. Wallace's opponents on the motion of the solar system in space. In the first place, the proof of this motion rests on

the assumption that if we take a sufficient number of stars their real motions in all directions will be equal, and that, therefore, the apparent preponderances which we observe in particular directions result from the real motion of the sun. But there is no impossibility in a systematic motion of the majority of the stars used in these researches which might reconcile the observed facts with a motionless sun. And, in the second place, if the sun is not in the exact centre of gravity of the universe, we might expect him to be moving in an orbit around this centre of gravity, and our observations on his actual motion are not sufficiently numerous or accurate to enable us to affirm that he is moving in a right line rather than in such an orbit. Indeed, the positions assigned to the apex of the sun's way appear to show a steady change as we use stars with diminishing proper motion which are presumably at increasing distances, and though other explanations of this circumstance may be given, one admissible hypothesis is that the different directions thus computed represent the tangent to the sun's orbit at different dates, and thus establish its curvature. To anyone, however, who realises the vast dimensions of the known universe, and the manner in which science is constantly opening out great new vistas into the unknown, a hypothesis like that of Dr. Wallace will appear to be exceedingly improbable, and I do not think the basis of observation on which it rests is sufficiently extensive and solid to justify its acceptance by the votaries of science.

I may remark that if, as I have suggested, the ether absorbs light, we have an explanation of many of the difficulties which arise in connection with this question. But apart from this hypothesis, meteors in space—cosmic dust—may absorb a sensible proportion of the light of luminous bodies, this proportion increasing with the distance. We could not discover this fact within the limits of the solar system, because the planets shine by reflected light, and the meteors or cosmic dust which intervened would reflect the light also, and being nearer to us than the planet would, in fact, increase its light, provided that their reflecting power were the same. The effect of their interposing between us and a self-luminous body would be quite different, and if they exist throughout all space, the greater the distance the more of the light they would (on the average) intercept. If sufficiently remote, the star would thus, for all practical purposes, be blotted out.

I may add that on the assumption of a finite ether forming an oasis in a desert universe, which seems to be Dr. Wallace's idea, not only is it unlikely that the centre of the universe would fall within the ether, but even if it chanced to do so, the ether would probably have a proper motion of its own which would soon carry it away from this centre. Further, assuming that life and intelligence could only be developed within the limits of this ether, and (as Dr. Wallace suggests) that the development would therefore be carried farthest in the case of the bodies that had been longest in it, I would expect to find these bodies not in the centre, but near the confines, at the opposite side from that at which they had originally entered it.

W. H. S. MONCK.

British Ornithological Notes.

Conducted by HARRY F. WITHERBY, F.Z.S., M.B.O.U.

The Meadow Bunting (Emberiza cia) in England.—At the meeting of the British Ornithologists' Club, held on January 21st last, Dr. R. B. Sharpe reported that he had recently examined a specimen of this bird caught near Shoreham, Sussex, at the end of October, 1902. There were two of these birds captured out of a flock of chaffinches and other birds, one had died and the other was in the possession of Mr. E. A. Hackett, of East Finchley. The Meadow Bunting is an inhabitant of Central and Southern Europe and Asia Minor, and has not been recorded before for Great Britain.

Great Bustard in Ireland (*The Field*, March 14th, p. 447).—Messrs. Williams & Son, the Dublin taxidermists, report the occurrence of two Great Bustards near Thurles, Co. Tipperary, in December, 1902. One of the birds (a female) was shot on the 20th of that month. The Great Bustard has not been recorded before for Ireland.

White's Thrush in Yorkshire (*The Naturalist*, March, 1903, p. 68).—A specimen of White's Thrush (*Turdus varius*) was shot in Luddenden Dean, near Halifax, on December 18th, 1902. The bird is now in the Halifax Museum, and a full account of it, illustrated with a photograph, appears in the *Halifax Naturalist* for February, from the pen of Mr. A. Crabtree. This bird is somewhat larger than a Mistle-Thrush, is mottled in plumage, and is generally to be found on the ground. It is an eastern species, and has seldom been recorded from Great Britain.

Lesser Whitethroat breeding in West Ross-shire (*Annals of Scot. Nat. Hist.*, April, 1903, p. 71).—Messrs. L. W. Hinxman and W. E. Clarke have identified a nest and eggs taken at Inverbroom, West Ross-shire, in 1896, as those of the Lesser Whitethroat. This bird breeds rarely in S.W. Scotland but has hitherto only been recorded as a passing migrant elsewhere in Scotland.

Rough-legged Buzzard in Ireland (*Irish Naturalist*, April, 1903, p. 111).—Mr. E. Williams records that a female specimen of *Buteo lagopus* was recently shot near Fivemiletown, Co. Tyrone. This bird is a rare visitor to Ireland.

The Status of the Goldfinch in Britain (*Zoologist*, 1903, February, pp. 70-72, March, pp. 104 and 105).—Observers in various counties continue here their opinions on the status of the Goldfinch in Great Britain.

Bean-goose in Outer Hebrides (*Annals of Scot. Nat. Hist.*, April, 1903, p. 119).—Mr. J. A. Harvie-Brown records that on March 21st last he received a specimen of this Goose for examination. The bird was sent from South Uist, and two others were observed at the same time. In the last edition of his "Manual of British Birds," Mr. Howard Saunders remarks that reported occurrences of this species in the Outer Hebrides, Orkneys and Shetlands, require confirmation.

British Bean-geese. By F. W. Frohawk. (*Zoologist*, 1903, February, pp. 41-45.)—Mr. Frohawk here reverts to the discussion of the Bean-geese (*see* KNOWLEDGE, November, 1902, p. 255).

On the specific validity of Anser rubrirostris (Hodgson) *and its position as a British Bird.* By F. Coburn. (*Zoologist*, February, 1903, pp. 46-52.)—This is a somewhat long and detailed description of the eastern form of the Grey Lag-goose obtained by Mr. Coburn from Limerick (*see* KNOWLEDGE, October, 1902, p. 231). Mr. Coburn is apt to become somewhat elated, and decidedly dogmatic, when on the subject of Geese.

On the Avifauna of the Outer Hebrides, 1888–1902. By J. A. Harvie-Brown.—Mr. Harvie-Brown sends me a most useful reprint from the *Annals of Scottish Natural History* of his series of articles, which bring the avifauna of the Outer Hebrides up to date.

Supposed Breeding of the Hawfinch in Ireland (*Irish Naturalist*, October, 1902, p. 250, and April, 1903, p. 111).—The Hawfinch has never been proved to nest in Ireland although it is often found there in winter. Notes have lately appeared, however, in the *Irish Naturalist*, stating that Mr. Bedford has seen, near Straffan House, Co. Kildare, a few pairs of these birds all through the nesting seasons of every year since 1896, and that last year he saw a Hawfinch feeding its young.

All contributions to the column, either in the way of notes or photographs, should be forwarded to HARRY F. WITHERBY, *at the Office of* KNOWLEDGE, 326, *High Holborn, London.*

Notes.

ASTRONOMICAL.—The most interesting recent event in astronomical matters is the discovery of a "new star" at the University Observatory, Oxford. On March 16th, in the ordinary routine of the work connected with the photographic chart of the heavens, a plate was exposed on a part of the constellation Gemini, and it happened that the new star was accidentally selected for the guiding star in place of the one intended. Subsequent examination of the plate indicated "an error in setting," and led to the recognition of the star as one not previously catalogued. The R.A. and Decl. are respectively 6h. 37m. 48·9s. and + 30° 2′ 39″ (1900). Photographs taken on February 24th, and earlier, did not show the star; on March 16th its magnitude was 7, and on March 27th it was 8·5. Observations by Mr.

Newall, Prof. Hale, and others, indicate that the spectrum consists of bright lines, and there is accordingly sufficient reason to suppose that the object is a true "nova," and not a long period variable of the Mira type.—A. F.

Botanical.—In *Torreya*, Mr. S. B. Parish gives a striking instance of the "Vital persistency of *Agave americana*." A specimen was planted on an estate in California in 1890, and having become too large, was cut down in 1900. Its leaves were sawn off and the trunk was allowed to lie on the ground till it should become sufficiently dry to burn. In May of last year, rather more than two years after being cut down, it put forth a flowering scape which grew, in its early stages, at the rate of six inches a day, till it reached a height of fifteen feet. This scape flowered, afterwards bearing fruit, and in November of the same year, three smaller scapes were produced. The author comments on the curious fact that this vigorous growth, remarkable as it would have been had it taken place in the first year, was deferred till the second year after the plant was cut down.

A flora of New Providence and Andros, Bahama Islands, appears in the last number of the *Memoirs of the Torrey Botanical Club*. It is based on a set of plants collected in the islands by Mr. and Mrs. J. I. Northrop, and is the work of Mrs. Northrop, assisted by various botanists. New Providence is one of the smaller islands of the group, while Andros is by far the largest, being nearly a hundred miles long and forty or fifty wide in its broadest part. The enumeration, which is preceded by an interesting introduction, includes 542 native species. Leguminosæ are most numerous, followed by Compositæ, Rubiaceæ and Euphorbiaceæ, in the order here given, and *Ipomœa* is the richest genus in species. Two new genera of palms are described by Mr. O. F. Cook, and miscellaneous new species, including a new *Vanilla*, are now published. It is worthy of note that fifteen genera are found in the enumeration which have not previously been reported from the Bahamas.—S. A. S.

Zoological.—Remains of man-like apes are of such rare occurrence in the fossil state, that the description of two molar teeth from the Tertiary deposits of the Vienna basin by Dr. O. Abel (*Centralblatt für Mineralogie, &c., 1903*), is a matter of very considerable interest. The one specimen is referred by the author to a new genus and species, under the name of *Griphopithecus suessi*, while the other is regarded as representing a new species of the well-known genus *Dryopithecus*, for which the name *D. darwini* is suggested. As regards the first, all that can be said is that it indicates a member of the group to which *Dryopithecus* belongs. By some writers it has been suggested that the latter genus is very closely related to man, but this idea is discountenanced by the great relative length of the muzzle and the small space for the tongue. It may be added that recently teeth of another man-like ape from the Tertiary of Swabia were described under the name of *Anthropodus*; since, however, that term had been previously used in another sense, Dr. Abel proposes to replace it by *Neopithecus*.

Closely connected with the foregoing subject is a paper by Prof. A. Gaudry, of Paris, published in *L'Anthropologie*, on certain human remains recently obtained by the Prince of Monaco at Baoussé-Roussé, near Mentone. The jaws of a young man are remarkable for the enormous size of the teeth, especially those of the cheek series, and the great relative development of the last molar or "wisdom tooth." That they indicate a very primitive type of the human race is undoubted. Whether, however, they are sufficient to prove, as M. Gaudry suggests, an affinity between the early human inhabitants of Europe and the Patagonians, and thus that South America was the cradle of mankind, demands at least further consideration.

Much interesting information with regard to the giant land-tortoises, and the remarkable land and sea iguanas of the Galapagos Islands will be found in a paper by Mr. E. Heller, recently published in the *Proceedings* of the Washington Academy of Sciences, forming part of a series descriptive of the Hopkins Stanford expedition to the islands in question. As might have been expected, most of the species of tortoises are diminishing very rapidly in numbers, and some appear to be well nigh extinct. Owing to the introduction of dogs, the land iguanas have been exterminated from all the islands save two, but the marine species is still abundant.

In view of forthcoming changes in the administration of the menagerie in the Regent's Park, the following paragraph from the Report of the New York Zoological Park is of considerable interest. In that menagerie one of the most recent and important innovations is the establishment of a thoroughly organized medical department under the direction of a veterinarian and a well-known human pathologist. A pathological laboratory is in charge constantly of an assistant, and daily rounds are made by an officer of the medical staff in company with the curators of the respective departments. Full reports are being kept of the symptoms of animals of various types, and of the causes of death. From these records it is proposed to prepare a special work on the habits, care and treatment of animals in captivity.

The British Antarctic Expedition.—A summary of the news of the "Discovery" received by cable from Captain Colbeck, of the "Morning," may be of interest to our readers. The "Discovery" left New Zealand in December, 1901, and the "Morning" found her in MacMurdo Bay (Victoria Land), on January 23rd, 1903. The "Discovery" entered the ice pack early in January, 1902, in lat. 67° south. Proceeding along the edge of the great ice barrier, the explorers made repeated soundings. It was found that the barrier was presumably afloat, that it continued horizontal, and was slowly fed from the land ice. High snow slopes rose from its edge to an extensive heavily glaciated land, with occasional bare precipitous peaks. On February 3rd, the "Discovery" entered an inlet in the barrier in longitude 174°, and a sledge party examined the land as far as latitude 78° 50′. Near Mounts Erebus and Terror excellent winter quarters were found. The ship was frozen in on March 24th, and the expedition passed the winter in well-sheltered quarters, huts having been erected for living and for scientific observations. The lowest recorded temperature was 62° below zero, and the fact that the expedition wintered some 400 miles further south than any former expedition will make the magnetic and other records taken of very great value. Sledging was begun on September 2nd, 1902, parties being sent out in various directions. Lieutenant Royds, Mr. Skelton, and others made an expedition to Mount Terror, travelling over the barrier under severe sleighing conditions, with a temperature of 58° below zero. Commander Scott, Dr. Wilson, and Lieutenant Shackleton sledged southwards. A depôt was made 60 miles south of the ship, then the snow became soft, and sledges had to be hauled in relays. This hard and trying work lasted 29 days. Another depôt was then established in latitude 80° 30′ south. All superfluous gear was then discarded, and on December 15th a dash was made for the south. On January 1st, 82° 17′ south was reached, or 100 miles

further south than any previous record. The conditions were very trying, the dogs all died, and the sledges had to be dragged back to the ship, which was reached on February 3rd. The party found that ranges of high mountains continue through Victoria Land. Mountains 10,000 feet to 12,000 feet high were seen in latitude 82° south, and the coast line continued at least as far south as 83° 20', so that it seems that land stretches to the South Pole in a series of lofty mountains. Further details of all this successful work, and of the many collections and observations made, will be eagerly looked for, and it is hoped that an equally useful year's work will be accomplished by the expedition in 1903. The "Discovery" has been revictualled by the "Morning," and will winter again in the Antarctic. Lieutenant Shackleton has returned in the "Morning" owing to his health, which suffered greatly owing to the privations and hardships of the sledge journey. Lieutenant Mulock has taken his place.

EARTHQUAKE IN THE MIDLANDS.—The earthquake felt throughout the Midland counties on March 24th was not one of the first magnitude, even for this country. It resulted in but little damage to buildings; though its strength only fell short of that necessary for throwing down a few chimneys or cracking the walls of houses. The area disturbed by it includes the whole of Derbyshire and Staffordshire, and a very large part, possibly all, of the adjoining counties. The shock was felt as far north as Preston, Lancaster, Leeds and Harrogate; to the east, it was perceptible at Grantham, and to the south, it is said, at Evesham; that is, over an area of about 13,500 square miles. The position of the epicentre is not yet determined, but it will probably be found to be at no great distance from that part of Dovedale which lies west of Matlock. British earthquakes seldom last more than ten or fifteen seconds, but the duration of the recent shock must have been over, rather than under, half a minute. This was due to its division into two distinct parts, separated as a rule by an interval of a few seconds. On this point, the personal experience of observers is corroborated by seismographic evidence. An interesting record of the earthquake was given by one of Prof. Omori's horizontal pendulums installed in Birmingham, and shows clearly two large oscillations, the total duration of the shock, including the initial and final tremors, being about one minute. The earth-waves, according to Dr. E. Wiechart, were also registered at Göttingen, which lies about five hundred miles from the centre of disturbance.—C. D.

Notices of Books.

"PROBLEMS IN ASTROPHYSICS." By Miss Agnes M. Clerke. (A. and C. Black.) Illustrated. 20s. net.—It is the custom in England, in every great business firm, to go over the accounts periodically, to balance the gain and loss, to take stock of the assets of the company. The principle of a "periodical stock-taking" is no less a sound one when applied to a science than to a business concern, but it is less often put in practical working: and we feel proud that it is an English astronomer who has undertaken and carried through the audit for the most exact of all the sciences.

Miss Clerke's "Problems in Astrophysics" is indeed a great astronomical stocktaking. She lays plain before us the capital of our knowledge. She shows what are the sound branches from which advancement and profit may be expected. She exposes the unsound principles whose practice can only mean disaster, the theories so rigid and complete that they cannot expand to include new facts, and so impede progress. "Finality means stagnation." She writes down unsupported speculation as of no value whatsoever. "The 'floating of an idea' in the mind does not constitute knowledge; and a speculation is only valuable when it offers a definite starting point for practical research." She discounts any complex hypothesis "which raises more difficulties than it removes."

The book is divided into two parts. The second deals with the problems of sidereal physics; with those presented by various types of stars; with variable stars of all kinds; with spectroscopic binaries; and with nebulæ, "white" and "green." Our sun is a true member of the sidereal system, but from his proximity to us we can study him in detail as we cannot remoter suns, and so another series of problems connected with the solar surface and surroundings is presented in the first part. Though these two parts are for convenience treated separately, essentially the same problems enter into both, and a question in the one may find its answer or its corollary in the other.

In the first part it may be said that all problems lead up, more or less directly, for their solution to two questions. What is the cause and law of the sun's periodicity? What are the natures and laws and conditions in the sun's surroundings? These two questions are not distinct, they are bound up with each other, and the answer to one will certainly throw light on, if it does not completely solve the other. And is the first question solvable? Probably, if the law of periodicity be due to an external cause, but Miss Clerke believes it is not so due. The cyclical changes of the sun may be inherent, or "may simply characterise a stage of growth, and prove liable to modification and effacement. The study of variable stars will perhaps help to guide ideas as to the probabilities of the case." So Miss Clerke states the case and leaves it. It is indeed a hard problem to pierce below the sun's photosphere and understand the conditions imposed in a state so unattainable in our earthly experience. And here we must express regret that Miss Clerke has omitted all discussion of both planets and comets on the plea that they "belong to the theoretical and descriptive departments of the elder celestial science." In Jupiter we have a state of things that bears directly on the question of the solar surface markings, of their periodicity, and of their connection with rotation.

In the second part, Miss Clerke assumes that time is the principal factor in the evolution of the type of a star; other factors, such as mass, modifying but not determining the type. The order of succession of the four chief families, she says, leaves little room for doubt. Nebulæ are the matrices of stars; of these are, first, helium stars; then these pass by fine gradations into Sirian: the Sirian by turn into solar; and these again into stars with fluted spectra. It is assumed that photospheres of helium and Sirian stars are "unveiled," and that those of solar are "veiled," but this seems scarcely axiomatic; similarly the assertion, on Dunér's authority, that the absorption in sun-spots is gaseous, namely that there is no increase in "general absorption" in the umbra, is by no means proved to hold good at all times and in all spots. By variable stars, the question of the sun's periodicity is presented again in a more acute form, and the constitution of "green" nebulæ raises many points that urgently call for elucidation from laboratory experiments.

It is a veritable *tour de force* to have brought out two such books as the fourth edition of "The History of Astronomy in the XIXth Century," so largely a new work, and "Problems in Astrophysics" within a few months of each other. We must confess to having opened the second of the volumes with a certain amount of trepidation; the first was of such a high order that it did not seem possible that Miss Clerke's strength would permit her in so short a period to produce a work of even equal excellence. But of her three great works, "The System of the Stars," "The History" and "Astrophysical Problems," we can unhesitatingly affirm that the latest is of even more value and is the outcome of even profounder thought than its two predecessors. There is one defect for which the publishers are to blame. Miss Clerke's book is emphatically one that will *not* be placed in that bookcase which is never opened. Is it right to issue such a standard book with its pages uncut, so that when the paper knife has done its work, the edges form an ideal lodging for the dust and microbes of the world?

"AN INTRODUCTION TO CELESTIAL MECHANICS." By F. R. Moulton, PH.D., Instructor in Astronomy in the University of Chicago. (Macmillan.)—This work will be of very great assistance to those students of Formal Astronomy (to use a particularly happy phrase of Dr. Moulton) who wish to connect mechanical and physical causes with their observed phenomena. In a book numbering less than 400 pages, and dealing with a subject so wide and so abstruse, it has been necessary to assume

that the reader knows much concerning the questions, and that he is acquainted to a considerable extent with mathematical processes. But, granted that, the working out of the various problems is presented with clearness and judgment. Dr. Moulton deals with rectilinear motion, with the problem of two bodies, with the problem of three bodies, with various perturbations, and with the theory of determinations of the elements of parabolic and elliptic orbits. Amongst many interesting details we may mention one in particular in connection with the Gegenschein. In the problem of three bodies—the sun, the earth, and a third body infinitesimal as compared with either—assume the origin of co-ordinates at the centre of mass and the axis of x as the moving line joining the circles of the sun and earth, both of which are supposed to move in centres round their common centre, the plane of $x\ y$ being the plane of their motion. Assuming that the infinitesimal body is also moving in this plane, Dr. Moulton finds the locus referred to the rotating axes, of those points in space where the velocity of the particle is zero. On this locus there are three double points on the x-axis, one lying between the sun and earth, and one on each side of these two bodies. Assuming the circularity of the earth's orbit, the double point which is opposite the sun is distant from the earth 930,240 miles, and at this point an infinitesimal body should just escape eclipse. If the infinitesimal body should arrive near this point under initial conditions (defined by equations too long to quote here) it will revolve in an ellipse round the point of equilibrium, and the major axis of the ellipse lies along the axis of y. If the initial conditions are very approximately complied with, the small body will move in an ellipse for a considerable time, but will eventually depart far from it, and it would be possible to have any number of infinitesimal bodies revolving around the same point without disturbing each other. If, therefore, a great number of meteors were moving in the plane of the earth's motion under the required approximate initial conditions, they would appear as a hazy patch of light with its centre at the anti-sun and elongated along the ecliptic, and this agrees substantially with the observations of Backhouse and Barnard. If Dr. Moulton's solution is the true explanation then the Gegenschein is not closely connected with the Zodiacal Light. True, Dr. Moulton says: "It is certain that the meteors are exceedingly numerous, as many as 8,000,000 striking into the earth's atmosphere daily according to the late Professor H. A. Newton, and it is only reasonable to suppose that they cause the Zodiacal Light, which is very bright compared with the Gegenschein." Dr. Moulton does not, however, give his reasons for assigning the origin of the Zodiacal Light to meteors, and we do not see that it follows from any one of the propositions here discussed.

"THE TWENTIETH CENTURY ATLAS OF POPULAR ASTRONOMY, COMPRISING IN TWENTY-TWO PLATES A COMPLETE SERIES OF ILLUSTRATIONS OF THE HEAVENLY BODIES." By Thomas Heath, B.A., First Assistant Astronomer, Royal Observatory, Edinburgh. (W. & A. K. Johnston, Limited, Edinburgh and London. 1903.)—This very handsome volume is, so far as its plates are concerned, essentially a new edition brought up to date, of Hind's Atlas, so popular forty years ago. The letterpress is largely new, and is due to Mr. Thomas Heath, First Assistant at the Royal Observatory, Edinburgh. Taking the plates first, the old ones were very admirable at their original date, and were finished with a care much greater than was at all usual at that time. But it may be questioned whether we are not now in a position to exact a higher standard. Plate XII. (views of nebulæ) is by no manner of means satisfactory. Apparently, the blue ground has proved utterly unsuitable for the reproduction of nebular photographs, and this Plate in consequence is worse than misleading. Plate X. (of comets) is not quite so bad, but here the most recent comet given is that of 1882. There have been many since that date more significant as to their structure than any shown here. Mr. Heath has fulfilled his difficult duty of bringing the letterpress up to date with considerable skill, but every here and there a little point suggests an oversight in the revision, or at least an incompleteness. To take a few instances:—The only reference as to the contour of sunspots is to Prof. Wilson's theory, illustrated by a rather crude diagram; Sir George Airy's determination of the density of the earth is the most recent one given; the chapter on meteors contains no reference to anything later than the shower of 1866, save for the fall of a single meteorite in 1890; the Zodiacal Light is "supposed to be due to sunlight reflected from minute meteoric particles crowding the region between the sun and the orbit of Mercury." Still, with all these imperfections, the book is a handsome and a useful one. Chapters X. and XI. on the moon and eclipses are especially well illustrated.

"WAVES AND RIPPLES IN WATER, AIR AND ÆTHER." By Prof. J. A. Fleming, F.R.S. Pp. 299. Illustrated. (S.P.C.K.) 5s.—The title of this book comprehends the most important branches of physics; for, according to modern conceptions, wave motion accounts for the greater part of physical phenomena. Waves and ripples in the air lead to sound and music, and in the æther they give rise to light and electricity. Prof. Fleming had therefore a wide subject to deal with when he gave the lectures at the Royal Institution, which are reproduced in the volume under notice. Everyone who sees this book will be glad that the lectures are now available to a wider audience than that of Albemarle Street, for they are full of interest and instruction. The style is easy and pleasant to read, the experiments and other examples are striking, and the illustrations are clear and attractive. Prof. Fleming knows how to deal with a subject in a manner which claims attention and commands respect for the dignity of science; for this alone his book merits many readers. No better popular yet scientific account of the principles upon which wireless telegraphy is based could be desired than this volume affords, and among similar subjects effectively dealt with are the electron theory of electricity, the relations between light and electricity, motions of vessels in relation to waves in water, experimental tanks for the study of motions of ships of various designs, earthquake waves and the phonograph. Every page contains an interesting statement of fact or principle, and we urge all who desire to enrich their knowledge to obtain a copy of Prof. Fleming's book.

"PUBLICATIONS OF THE MAHARAJA TAKHTASINJI OBSERVATORY, POONA." Vol. I. "REPORT ON THE TOTAL SOLAR ECLIPSE OF JANUARY 21-22, 1898, AS OBSERVED AT JOUR, IN WESTERN INDIA." By Kavasji Dadabhai Naegamvala, M.A., F.R.A.S., etc., Director of the Observatory.—It is nearly five years since the total solar eclipse occurred, the observations of which Prof. Naegamvala here reports. This delay is certainly much to be regretted, since two important eclipses have taken place in the interval, but in all probability the delay has arisen from causes quite beyond Prof. Naegamvala's control. The report bears strong evidence to Prof. Naegamvala's energy and power of organisation in bringing together and equipping so well-ordered a force for the observation of the eclipse. The most important work which he undertook was spectroscopic, and his most powerful instrument a Cooke triple achromatic, of six inches aperture, used with two prisms of 45° as a prismatic camera, and a series of successful photographs were taken with it. Of these, the first plate, taken at the instant of second contact, appears of most importance, and a long list is given of the bright lines measured upon it. This plate was specially exposed for the purpose of the study of the "Flash," and it is disappointing to find that Prof. Naegamvala does not venture to draw any conclusion as to the relation of the "Flash" to the Fraunhofer spectrum. He quotes, indeed, at length Mr. Maunder's statement of the points at issue from KNOWLEDGE for August, 1898, but has nothing to say as to the light which his results can throw upon them. With some of his smaller spectrographs he obtained important spectra of the corona, beside photographs of the corona itself with various instruments. A fine composite drawing of the corona from the latter photographs made by Mr. Henry Cousens, Superintendent of the Archæological Survey to whom several of the plates of spectra, and some very interesting studies of coronal types are also due, forms the frontispiece to the volume.

"THE FLORA OF THE EAST RIDING OF YORKSHIRE, INCLUDING A PHYSIOGRAPHICAL SKETCH." By Jas. Fraser Robinson. (Brown & Sons. 1902.) 7s. 6d.—The North Riding of Yorkshire has had an able botanical exponent in Mr. J. G. Baker, and the West Riding in Dr. Arnold Lees. Now the East Riding has also a flora of its own, thanks to Mr. Robinson and the Members of the Hull Scientific and Field Naturalists' Club. Among the many local floras published of late years the present book will take a high place. There is throughout a good sense of proportion; the general features

are ably dealt with, and the work is not weighted with an unwieldy mass of detail. The introductory matter is especially well worked out. The geology and physiography of the area are described clearly and well, and their relation to the flora fully set forth. The flora is analyzed according to petrological conditions, and also according to water supply and nature of soil. The history of the progress of research in the flora of the East Riding is sympathetically treated. A condensed account of local meteorology is also given, sufficient for the needs of the botanist. It is stated that "alien plant names are always in italics" in the body of the book, but this salutary rule is not invariably carried out, and certain aliens and casuals appear in the same type which is accorded to native species. The "incognita," too, which include some records admittedly erroneous (*e.g.*, *Carex Davalliana*), are printed without any distinguishing mark as regards type, which is hardly satisfactory. But these are minor blemishes.

"NIELS HENRICK ABEL : MEMORIAL PUBLIE À L'OCCASION DU CENTENAIRE DE SA NAISSANCE." Edited by Elling Holst, Carl Stormer, and L. Sylow. (Kristiania : Jacob Dybwad. London : Williams & Norgate. 1902.)—Now that Abel's great mathematical discoveries have been universally acknowledged, it is as easy as it is useless to sing his praises. Let us rather avail ourselves of the story of his life, as told by M. Elling Holst in this fitting commemoration of the centenary of Abel's birth, and take a lesson from it. Instead of a man on whom fortune smiled, we find a young lad with a passionate enthusiasm for mathematics, struggling in the face of adversity, whose academic *Alma mater* denies him the bare means of subsistence, whose career is a short but hard fight against ill fate. Both at school, after his mathematical ability had been discovered by Holmboe, and at the University of Christiania, his life is on the whole a happy one, and at the end of his academical *curriculum*, he obtains a scholarship to enable him to travel abroad for two years. But before that time has elapsed, the chair of mathematics, which he of all men is best qualified to fill, has been awarded to his old teacher, Holmboe ; the experienced teacher, as so often is the case, being preferred to the rare genius. On his return home, he seeks to obtain the bare means of subsistence while he is carrying on his important researches, but his appeal to those in authority meets with a curt refusal, and it is only by repeated applications that he obtains a pittance less than that of any other "privat-docent," indeed, as M. Holst puts it, "too small to live or die on." From Crelle, in Berlin, he has received every encouragement. Crelle publishes his works and will gladly find employment—such as he can offer—for him. At Paris, he as a foreigner has met with but little success, and his paper containing the epoch-making discovery known as Abel's theorem has been laid aside and neglected by those to whom it was confided for publication. Instead of remaining under Crelle he considers it his duty to return to his own university, where he becomes a cat out of kind, a sort of *homme incompris*. His extraordinary genius finds no opening in an academic body, the ruling powers of which might be described as good but not exceptional men. The discovery that another worker, Jacobi, is developing a theory of elliptic functions on parallel lines to Abel's, combined with the hardships he had undergone, no doubt tended to bring about the illness by which Abel's career was terminated, two days before his good friend Crelle wrote definitely informing him of his appointment to a chair at Berlin. This was in April, 1829, only three and a half years after the commencement of Abel's foreign expedition.

Now what makes the story of Abel's life the more painful is the thought that a man of Abel's type would fare no better at an English university at the present day than Abel himself did at Christiania nearly three-quarters of a century ago. Like Abel, he would find plenty of "kind friends" who would tell him that his work would secure for him a world-wide reputation, but they would not raise a hand to give him substantial assistance. They would counsel him to continue his researches and to wait on, because "an opening for him would be sure to occur very soon," but when the opening did occur, they would vote for the man of mediocre ability as against the genius. If Oxford and Cambridge do not possess Abels, they at any rate train mathematicians and others up to the stage when they may be competent to undertake research work that is useful and interesting. That these men are advised to remain at the University with the prospect of obtaining appointments, which are afterwards refused them and allotted to others, is an experience far more common than is generally known. The practice is a mischievous one which cannot be too severely condemned, and it is to be hoped that those who are in danger of falling victims to it will take warning by the fate of Abel.

BOOKS RECEIVED.

Encyclopædia of Accounting. Vol. I. Edited by George Lisle, C.A., F.F.A. (Wm. Green & Sons.)

The Soil. By A. D. Hall, M.A. (Murray.) 3s. 6d.

Photographic Lenses. By Conrad Beck and Herbert Andrews. (R. & J. Beck, Limited.) Illustrated. 1s. net.

Agricultural Geology. By J. E. Marr, M.A., F.R.S. (Methuen) Illustrated. 6s.

Open-Air Studies in Bird Life. By Charles Dixon. (Griffin) Illustrated. 7s. 6d.

Laboratory Guide for Beginners in Zoology. By Clarence Moores Weed, D.Sc., and Ralph Wallace Crossman, B.A., M.Sc. (Heath.) Illustrated. 2s. 6d.

Guide to the Early Christian and Byzantine Antiquities. (British Museum.) Illustrated. 1s.

Country Gentlemen's Estate Book, 1903. (Country Gentlemen's Association, Limited.) 5s. net.

School Geometry. Parts I. and II. By H. S. Hall, M.A., and F. H. Stevens, M.A. (Macmillan.) 1s. 6d.

Reports on the Administration of Rhodesia, 1900-1902. (British South Africa Co.)

Transactions of the Royal Scottish Arboricultural Society. Vol. XVII. Part I. (Edinburgh : Douglas & Foulis.)

Zoological Gardens, Giza, near Cairo, Report for the Year, 1902. By Stanley S. Flower, Director. (Cairo : National Printing Department.)

Wireless Telegraphy and Telephony. By Dr. Maurice Ernst. (Rentell.) 1s.

Rhodesia Museum, Bulawayo. Annual Report, 1902; and Special Report—The Zimbabwe Ruins. By F. P. Mennell, F.G.S.

19th Annual Report of the Bureau of American Ethnology, 1897-98. Parts 1 and 2. By J. W. Powell. (Washington : Government Printing Office.)

Tsimshian Texts. By Franz Boas. (Bulletin 27, Smithsonian Institution.) (Washington : Government Printing Office.)

Human Origins. By Samuel Laing. (Watts & Co.) 6d.

Leeds Astronomical Society—Journal and Transactions during the year 1902. (Wesley.) 2s.

Cambrian Natural Observer, 1902. Edited by Arthur Mee. (Cardiff : Evans & Williams.)

Symons's Meteorological Magazine. Edited by Hugh Robert Mill, D.Sc., LL.D. April, 1903. (Stanford.) 4d.

Lenses for Photography. (Taylor, Taylor & Hobson, Ld.) Free.

Photographic Catalogue. (Jas. Woolley, Sons & Co., Ld., Manchester.)

CLOUDS AS SEEN FROM CLOUD LEVEL.

By REV. JOHN M. BACON, F.R.A.S.

IN aerial travel there is often some little difficulty in determining what is actual cloud level ; and in consequence it is not always easy to form a correct idea of the true aspect of clouds. If cloud be lying beneath an observer it may be quite impossible for him to judge by the eye whether the upper limit be a hundred feet or a thousand feet, or even twice that distance below him ; and this will make all the difference in the estimate that is made of the true form and composition of the cloud-mass. No doubt the remarkable transparency of aerial space at high altitudes, and the absence of any intermediate objects to aid the eye in forming a right judgment of scale or distance is the chief cause of the difficulty referred to. Kinchinjunga, as seen in exceptionally transparent air from Darjeeling, often seems to the eye scarcely more than a mile distant, though in reality it is forty, and obviously the true character of that mountain's slopes will be more or less accurately described by an observer according as its true distance is duly estimated.

The accompanying group of photographs show the strikingly different aspects of the upper surface of a cloud-mass as seen from different heights. The first photograph

was taken practically at the cloud level, the second at about a thousand feet above, and the third at fully a mile above the limit of the cloud. Yet even in this last case the cloud appeared but as an extended floor lying only a few feet below the car; and as judged by the eye it seemed inexplicable how the trail rope, a hundred yards long, was not immersed in it. Thus anyone who had not tested the depth of the intervening distance and describing simply what he appeared to see, would record that the upper surface of the cloud in question closely resembled a snow field whose surface had been slightly ruffled into shallow parallel ridges. If the same imperfectly informed individual were judging simply from such appearances as are presented by the second photograph he would give a modified but scarcely more accurate description.

Fig. 1.

Fig. 2.

The true nature of the cloud limit as investigated from its own level will be discussed directly. Meanwhile it will scarcely need pointing out that what a balloonist commonly sees on a cloudy day at cloud level is simply a dense stratum of mist, such as constantly rests on the surface of the earth, often upwards of a thousand feet in depth, dark in its lower regions, but growing lighter as you ascend until, if the sun be brightly shining above, you are on reaching the fringe bathed in an atmosphere of the most dazzling luminosity. Then in a general way as you emerge you find yourself surrounded by huge fleecy billows tossed mountains high, the true regularity of which only becomes apparent when you have climbed high enough to look down on the billow crests and find them in arrangement (as shown in Fig. 1), somewhat resembling the surface of a storm-tossed sea, though they have always appeared to me to resemble more closely the arrangement of wreaths of smoke trailing behind a passing train, or streaming from an ill-stoked factory chimney, and due to the rhythmic "cling and release" of the gaseous cloud ere it issues from the aperture

Fig 3.

A closely analogous appearance may often be noticed when a thin layer of snow on a level close-cut lawn has been thawing under the action of a breeze of some little strength. The snow may be seen to thin away, not so much in patches as in furrows, leaving broken but regular ridges lying athwart the direction in which the wind is blowing.

When cloudlets wander by at nearly the level of the observer—and it is astonishing how often such cloudlets though at close range will be found drifting at a different speed from that of the balloon—they are seldom of the roughly globular masses which, through foreshortening, they appear from below. They are generally rather elongated columns leaning forward with the wind. Larger detached cloud-masses may retain their heaped appearance, but as they are in a condition of wasting away their entire surface at a close view is frayed and withered.

Such a cloud is shown in the accompanying photograph, and bears the shadow of the balloon somewhat strikingly displayed upon it. Indeed this shadow, projected with

The Shadow of the Balloon may be seen upon the Cloud.

clearly-defined outlines upon so filmy a background, and surrounded, as it generally is, with iridescent rings, invisible in a photograph, but of great beauty, never fails to elicit expressions of delight and astonishment from those who behold it for the first time. The clouds I am here describing are in their nature and composition very different from the compact and newly-created cumulus cloud, whose surface is of closer texture, and whose level underside betrays so clearly the plane of demarcation of the air stratum above which it has been formed, and on the surface of which it, so to speak, floats. The most remarkable levelling of the under-surface of a cloud occurs perhaps when the cloud-masses are drifting up from a moist quarter, while below them is flowing a dry air stream, most often from the east. Under these circumstances the base of the cloud is, as it were, mown perfectly flat.

Another remarkable feature, to be noticed on the upper surface of clouds, and which has been revealed probably

only to the aeronaut sailing at their level, is when a cloud stratum assumes the appearance of long rollers, due apparently to the action of enormous waves of air. Such appearances have been more particularly noted on the Continent, where the rollers have been estimated as measuring a third of a mile from hollow to hollow, and in this strikingly bearing out Professor Helmholtz's theory with regard to the extent of atmospheric waves.

It is when a cloud stratum has been subjected for hours to the action of a hot sun that it will begin breaking up into chinks and hollows, which come as a revelation to the aerial voyager. These are seen by him when at a short distance above the cloud level long before any rifts in the cloud ceiling are noticeable from the earth. At first they appear as mere dark pits or clefts; and, if the sun be low, may scarcely be distinguished from the mere furrows or hollows of the cloud thrown into shade. But attentive watching will presently reveal the fact that brighter objects on the earth—roadways, water, or white buildings—are flitting past underneath.

Sometimes, however, it is the observer below whose vision can best gauge and penetrate a cloud. For instance, the density of an attenuated cloudlet is apt to be wrongly estimated by an observer who is immersed within it. Thus a balloon, as observed from the earth, may be only thinly veiled by a cloud which nevertheless completely blots out all objects from the aeronauts themselves.

It is no uncommon experience when level with a bed of stratus cloud to see cumulus cloud masses rising and rearing themselves into heaps above. A very similar phenomenon, and one of rare beauty, is often to be seen from aloft on overcast days, when perhaps a leaden sky overhangs all the land. Under such conditions I have found the cloud bed, which I have probably entered before an altitude of 2000 feet has been reached, to be upwards of 1000 feet thick, and the upper surface to be of one general level extending as far as the eye can reach. Here and there, however, this general level will be reared into a stately dome without assignable cause, and suggesting the thought that a mountain peak must be beneath. Professor McAdie has obtained some magnificent photographs from Mount Tamalpais of this appearance, which he has designated cloud pyramid, and which he has discovered to manifest itself over land which is perfectly level. The phenomenon may occur towards evening, when the upper air is beginning to reach a higher temperature, and the cloud column must be attributed to ascending currents. Instead of assuming the form of dome or pyramid the mass upreared will sometimes simulate the appearance of a vast wave breaking into spray, and attended as it were with veritable "spindrift" borne away on the gale. Under these circumstances, it seems little less than a mystery that such a fugitive and ethereal object can possess so much permanence as to remain practically unaltered in appearance for a long period.

There are certain days when though the sky may be devoid of actual cloud, it is full of an indefinite haze which is the ultimate form of cloud. On such days you may ascend, and by the time the first mile has been climbed you may be looking down on a universal lake of haze, the upper limit of which is as well defined and level as the surface of still water, while overhead the sky is absolutely clear.

As to the upper clouds which the balloonist in a general way does not reach, it can only be said that from ordinary "cloud level" they appear more clearly defined and nearer than when viewed from earth, not merely because they are actually beheld at closer range; but also because they are now seen in a transparent sky of purest and deepest blue.

MICROSCOPY

Conducted by M. I. CROSS.

THE MOUTH PARTS OF THE TSETSE FLY.

By W. WESCHÉ, F.R.M.S.

(*Continued from page* 92.)

There is little doubt that the suctorial mouth parts in the Mucidæ were evolved from an ancestor with complete biting mouth parts, and it is curious and interesting to find that this suctorial mouth is again modified in the Tsetse into a biting, or blood-sucking mouth. But there is no retrogression to the earlier type, the mandibles do not emerge from the upper part, or the maxillæ from the lower, but the development is on fresh lines. The lower lip has become horny, by a simple process of the chin plate, the *mentum*, having spread over its membrane, at the same time contracting it, and shrinking it into a slender tube. But at the extremity, instead of the tracheated discs, we find the tip modified into a series of laminated hard ridges, and at the extremity of these ridges the teeth, which in the suctorial mouth were inside and lower down (Figs. 1 and 2). The reason of these changes is obvious; it is necessary for the proboscis to become hard and strong in order to penetrate the thick skin of large herbivorous mammals. On examining the tip of the part with higher powers the resemblance of the laminated structure to that on the ovipositor of some flower-haunting Hemiptera

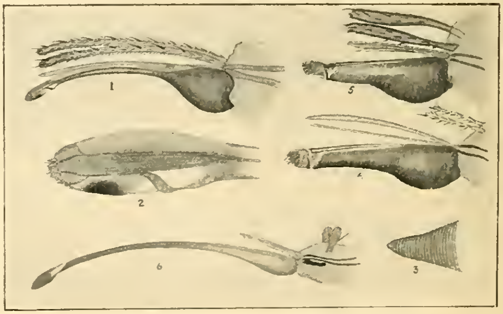


FIG. 1.—Mouth parts of Tsetse fly (*Glossina morsitans*). (All lateral views.) FIG. 2.—The tip of the proboscis of the Tsetse fly more magnified, showing chitinous ridges and teeth. FIG. 3.—Tip of ovipositor of *Capsus laniarus*, showing the chitinous ridges used in piercing stems of plants. FIG. 4.—Mouth parts of *Stomoxys calcitrans*, L., a very common British blood-sucking fly. FIG. 5.—Mouth parts of *Hæmatobia irritans*, L., a British blood-sucking fly. FIG. 6.—Mouth parts of *Prosena sybarita*, F., a British flower-feeding fly.

is evident. The ovipositor in these insects is used to bore into wood (Fig. 3). On the suctorial mouth there are two transverse levers which expand the discs; these are very well marked, and obviously homologous in the Tsetse fly. The lancet (hypopharynx) seems to have weakened and the upper lip to have atrophied. This is probably occasioned by disuse, though in *Stomoxys* both these organs are present (Fig. 4). The palpi have greatly lengthened, showing that they have important work to do. In our English *Hæmatobia irritans* this has also taken place, but in *H. stimulans* and *Stomoxys calcitrans* we find them of the usual size, or even in a degenerate state (Fig. 5).

The proboscis of *Prosena sybarita* is even more like that of the Tsetse than those mentioned, but its use is quite different; it is used to suck the juices from the long tubes of flowers, but

there can be little doubt that the development has been on similar lines, though *P. sybarita* has the tracheæ still showing at the end. This is a stage through which *Glossina* undoubtedly passed before it developed the chitinous ridges that now characterise it (Fig. 6). The large swelling at the base of the proboscis was for some time thought to be the receptacle for the Tsetse poison. This was plausible, but has no foundation in fact, as this part is simply full of the complicated muscles necessary for the working of the proboscis. The herptomonads which are the pathological element are an accident, and even an unfortunate accident regarded from the Tsetse point of view. They form part of the food of the insect, sucked with the blood from the antelopes and zebras, and may be found in any part of the alimentary canal. Till the Tsetse has sucked the blood of an infected animal it is like the Anopheles mosquito in a similar state, perfectly harmless.

I have been asked to say where specimens of Tsetse can be obtained. I am afraid that they are very difficult to come by. The only chance is through friends in Africa, and that chance but a remote one, as man avoids the Tsetse country as much as possible. Even if the flies can be caught it requires a certain measure of skill to set them properly, and they will probably arrive in a very unsatisfactory state.

In the Natural History Museum at Cromwell Road is one of the earliest specimens obtained. This was sent home by Dr. Livingstone, and is simply the insect crushed on a piece of paper. This is cherished as a relic of the great explorer, but is a sorrowful object to an entomologist. I have also seen some that another great traveller, Captain Speke, collected; these were properly pinned and set, and, considering how many years they have been in the Museum, are in fairly good condition.

The figures are drawn from preparations, cleared and mounted with pressure.

"THE HELMHOLTZ THEORY OF THE MICROSCOPE."

The meeting of the Royal Microscopical Society on March 18th was devoted to a paper by Mr. J. W. Gordon on "The Helmholtz Theory of the Microscope." Mr. Gordon's paper was suggested by an article which Helmholtz contributed in 1874 to *Poggendorf's Annalen* under the title, "The Theoretical Limit of Resolving Power in the Microscope"; "the merit of which"—in Mr. Gordon's opinion—"lies not in this formal result (that is, the demonstration of a definite limit of resolving power), which is, in fact, not successfully established, but in the line of investigation which Helmholtz here strikes out, and without following it to its practical issues, pursues far enough to present his readers with a surfeit of interesting and valuable suggestions. These suggestions are, many of them, so obscure and conveyed by such subtle hints that they may well escape attention, and apparently they have escaped attention to the present day."

Mr. Gordon attempted the extremely difficult task of giving an account of Helmholtz's paper without "its somewhat repulsive mathematical garb," a task the more difficult in the present case because Helmholtz himself, in a postscript, frankly acknowledging the priority of Prof. Abbe with regard to the enunciation of the several theorems contained in his paper, suggests as the latter's only scientific justification just the mathematical proofs of those theorems which Abbe had not then published.

Briefly stated, Mr. Gordon's paper gives first a non-mathematical dissertation on the theory of diffraction and diffraction gratings, which, he says, Helmholtz takes for granted, and writes as abstrusely about as the most hardened mathematician. Then follows a long section on the famous Sine-condition, which has probably suffered most—as compared with Helmholtz's lucid paper—by the effort to suppress mathematics. Finally the contraction of the emergent pencils with increasing magnifying power is discussed as affecting the brightness of the image, the obtrusiveness of entoptic appearances, and especially the rapid widening of diffraction fringes.

It is in this last section that Mr. Gordon finds fault with Helmholtz's reasoning and endeavours to prove him in the wrong. It is, however, to be feared that not many scientifically educated microscopists will prefer Mr. Gordon's arguments to those of the great physicist.

Having convinced himself that Helmholtz's reasoning as to the limit of resolution is quite wrong, Mr. Gordon once more tries to suggest improvements of the microscope which would or might extend its powers. It will be remembered that about two years ago, in a paper read before the Royal Microscopical Society, Mr. Gordon suggested that the "antipoints" might be made as small as desired, and the definition accordingly improved, by some arrangement of lenses behind the objective. This time we are offered an oscillating screen. The image projected by the objective is to be focussed on a finely ground glass-screen, which is, moreover, to be set oscillating in order to render its grain invisible; and the image so projected is to be viewed by a second microscope so as to get a high magnification without an excessively contracted emerging pencil.

In a first appendix, Mr. Gordon gives what he believes to be a proof of the Sine-law, or, rather, of a Sine-tangent law: he also endeavours to show that Hockin's elegant proof—as accepted by Prof. Sir Silvanus Thompson, Dr. Czapski, and other authorities—is wrong. In a second appendix he tries to prove by a kind of graphical integration that lines much closer than would follow from Helmholtz's formula can be resolved.

A third note tries to prove Helmholtz in the wrong as regards the impossibility of suppressing diffraction-phenomena; and a fourth points out an error in a published translation of Helmholtz's paper.

The late hour at which the reading of the paper was concluded unfortunately cut short what might evidently have been an interesting and instructive discussion. Still, it sufficed to show a strong conviction in certain quarters that Mr. Gordon had over-estimated the importance of "the Helmholtz theory," and had, at the same time, not done justice to the lucid reasoning of the original paper.

Mr. Gordon's interpretation of the Sine-law was particularly objected to (he maintained that it applied to objects and images of sensible size, whereas it is obviously, as a strict mathematical theorem, limited to a surface element in the optical axis), and it was pointed out that he had not given Helmholtz's proof of the Sine-law proper at all, which Helmholtz deduced by integration from a more general one applying to all centred optical systems, but restricted to small angles of divergence and of incidence. Considerable doubt was also expressed whether the oscillating screen would put any detail into the image which could not be seen with a suitable eyepiece.

A careful perusal of the paper and a comparison with the original German paper of which it is meant to give an account must convince anyone familiar with optical and microscopical theory that it bristles with statements which invite criticism.

MONOCHROMATIC LIGHT (*Continued*).

The following list of light filters, any of which can be easily made, and will be found invaluable in photo-micrography especially, have been tried in actual working. They are from the formulæ of Dr. Nagel, of Freiburg, and with others of a similar nature are detailed in "Biological Laboratory Methods," by Mell.

ORANGE FILTER for the spectrum district between C and D.—Prepare a solution of acetate of copper, add a few drops of acetic acid, and then, drop by drop, a concentrated saffranin solution, until the solution will admit no more violet, blue, green and yellow light.

YELLOW-RAY FILTER.—Add to a saturated acid solution of acetate of copper a saturated acidified solution "Orange G." The liquid has a brown appearance, and passes only a small stripe of yellow light.

GREEN-YELLOW FILTER.—To a saturated solution of bichromate of potassium acidified with acetic acid, add crystals of acetate of copper, and heat the solution. The green liquid passes only monochrome green light.

BLUE-RAY FILTER.—A weak solution of methyl-green is mixed with acetate of copper solution until no red light passes.

Reference was made in the last number to the Gifford Screen for line F, and the special qualities of the acetate of copper screen, which has been previously described in these columns, should not be overlooked. This screen consists of a saturated solution of acetate of copper. The solution is placed in a trough which should have an interval between its back and front glasses of at least ⅝-inch. ⅝-inch exactly absorbs the red end of the spectrum when an oil lamp having a ½-inch wick is used. If a more brilliant illuminant be employed an increased width of trough might be also used without disadvantage.

NOTES AND QUERIES.

W. N. T.—The merits of all the microscopes you name are so close that it is impossible to recommend one in preference to another. So much depends on your future intentions, and if you propose to do progressive work preference should be given to an instrument which can have extra fittings added to it from time to time to make it quite complete. For the work you name, you would find a No. 2, or "B," ocular, in conjunction with 1 inch and $\frac{1}{6}$ inch objectives, the most serviceable. It is unlikely that you would require both the $\frac{1}{4}$ inch and $\frac{1}{6}$ inch; and I certainly should not advise the use of a deep-power eyepiece for the comparatively low-power objectives for continual work. Better results are always secured with eyepieces of low power.

W. Rogers.—(1) *Treatment of Fossil Deposits for Diatoms.*—Break deposit up into small pieces and boil in a strong solution of soda bi-carbonate, pour off from time to time the disintegrated material into a beaker, and continue the boiling until all the deposit has broken up. The soda solution must then be washed away and the diatoms boiled for about 15 minutes in nitric acid, and, when clean enough, wash away the acid with repeated changes of water, then boil up the diatoms in distilled water. (2) *Treatment of Sponges.*—If horny, boil in liq. potassæ, then wash spicules with water to remove all trace of potash and mount them in glycerine jelly or Canada balsam. Siliceous sponges must be boiled in nitric acid, then washed well with water and mounted in glycerine jelly or Canada balsam. For types in which siliceous spicules are embedded in horny matrix, boil in liq. potassæ for a few minutes to disintegrate the spicules, then boil in nitric acid to clean spicules, wash away acid with repeated changes of water and mount in glycerine jelly or Canada balsam. (3) *To make Camphor Water.*—Add some pieces of camphor to distilled water and let it stand for 24 hours, filter, and then you will have a 3 per cent. solution; water will not take up more. Another way: Dissolve some camphor in rectified spirit, add a few drops of distilled water, shake well for a minute, filter, and keep in a stoppered bottle. (4) I consider a 2 inch objective better for small seeds.

C. Zimmermann.—(1) The parasite on the portion of pear tree you send is the Pearl Oyster Scale (*Aspidiotus ostreaformis*). (2) The only fixing medium I know of for celloidin sections is Mayer's albumen, but I do not think any is required; the celloidin need not be removed. The tissue should be stained in bulk, embedded in celloidin, cut sections, place in absolute alcohol for about three minutes, clear in oil of origanum, and mount in Canada balsam. The celloidin will be invisible. (3) There is only one solvent for celloidin, viz., equal parts of absolute alcohol and ether.

Communications and enquiries on Microscopical matters are cordially invited, and should be addressed to M. I. CROSS, KNOWLEDGE *Office*, 326, *High Holborn, W.C.*

NOTES ON COMETS AND METEORS.

By W. F. DENNING, F.R.A.S.

GIACOBINI'S COMET (1902 D).—This small, distant comet is still visible in the evenings, and will be situated about 2° E.N.E. of *a* Geminorum at the opening of May, and moving slowly eastwards. Recent observations have fully confirmed the exceptionally great perihelion distance (258 millions of miles) derived from earlier computations. This distance is 118 millions of miles outside the mean position of the orbit of Mars and in the region of the minor planets. On May 1 the comet will be about 280 millions of miles from the earth.

PERIODICAL COMETS.—Several short-period comets, belonging to the Jovian family, are due to return to perihelion this year, but the conditions will be unfavourable in most cases, so that the objects will probably escape observation. Giacobini's comet of 1896 (V.), formerly supposed to have a period of 9 years, appears to revolve in only 6 647 years according to new elements computed by Ebell (*Ast. Nach.* 3848). It will return during the present spring, but only as a very faint object. Perrine's comet of 1896 (VII.) should pass through perihelion on April 26, and Ristenpart gives elements corrected for perturbation by Jupiter in *Ast. Nach.* 3841. But the prospect of seeing the object is extremely small, for when at its brightest in May it will have only half the light which it displayed when last seen in 1897 at Northfield, Minn., on which occasion the aspect of the comet was described as "most exceedingly faint" as viewed in a 16-inch refractor. Spitaler's comet, 1890 (VII.), is due in the summer, but it is a feeble object, and will not be sufficiently well placed to be re-observed. Faye's well-known comet ought to be fairly well seen in the autumn, and Brooks's comet (1889 (V.)—1896 (VI.)) will reach perihelion next December, but will be nearest to the earth at the middle of August. Its periodic time is 2592 days (7·1 years), and Seagrave has computed a search ephemeris from which we hope to give extracts in later months.

SOUNDS ACCOMPANYING METEORS AND METEORITES.—Casual observers sometimes report that they distinctly heard, simultaneously with the flight of a meteor, a hissing, rushing or whirring sound. Many instances of this might be quoted from descriptions of meteoric apparitions in recent years. But judging from the circumstances and from the nature of the evidence there seems little reason to doubt that in all such cases the contemporary sounds were either imaginary or produced from sources altogether different to those assigned. Sound is a slow traveller, and even admitting that a meteor penetrates the air to within 25 miles of an observer, the noise of its disruption or concussion could not reach him until 2 minutes afterwards unless there is some law of acoustics not yet understood.

In the case of a meteorite close to the earth's crust, and in the act of subsiding upon it, the conditions are essentially dissimilar, for its detonations may startle an observer before he sees the falling body strike the earth. This arises from the remarkable slowness of motion with which the object is travelling. Meteorites usually penetrate the soil to the depth of only a foot or so, from whence it is evident that their velocity can scarcely exceed a few hundred feet per second. The meteorite which fell at Wold Cottage, Yorks, on 1795, December 13, was dug out of a hole 18 inches deep. The meteorites of 1876, April 20, and 1902, September 13, embedded themselves to the same depth as that of 1795, while that of 1881, March 14, was discovered 11 inches below the surface.

The question of the precedence of sound in attracting attention to these events formed the subject of an interesting discussion at a recent meeting of the British Astronomical Association, but the matter seemed difficult to explain, as the speakers appeared to regard parabolic or planetary speed as one of the necessary features of falling meteorites. But atmospheric resistance, and, in lesser degree, terrestrial attraction, must exercise a great obstructive influence upon objects of this class, robbing them of their initial speed and direction, and ultimately causing them to descend upon the earth with a velocity comparable with that of terrestrial bodies. When the meteorite of 1881, March 14, reached the earth's surface its velocity was only 412 feet per second (1 mile in 13 seconds) according to some experiments specially carried out by Prof. Herschel. The object would have acquired this rate by falling freely through $\frac{1}{2}$ mile, while if vertically descending through 40 miles it would have reached the ground with a velocity nine times as great as that observed. "Schiaparelli has shown that if the law of resistance for planetary motions is similar to that derived from experiments with artillery, then a ball of 8 inches diameter and $32\frac{1}{2}$ lbs. weight entering the atmosphere with a velocity of $44\frac{3}{4}$ miles per second will on arriving at a point where the barometric pressure is still only $\frac{1}{760}$ of that at the earth's surface, have its velocity already reduced to $3\frac{1}{8}$ miles a second." Such meteors, therefore, as are sufficiently large and compact to be practically stopped in their courses before disruption and dissolution, will become cooler, and descend leisurely to the earth, sometimes travelling with a velocity less than that of sound, so that the intimation of their downfall is conveyed to the ear quicker than to the eye of a spectator who may happen to be near.

THE FACE OF THE SKY FOR MAY.

By W. SHACKLETON, F.R.A.S.

THE SUN.—On the 1st the sun rises at 4.37 and sets at 7.19; on the 31st he rises at 3.53 and sets at 8.2.

The minimum of sunspot activity seems now to be left well behind, and spots of considerable size have been recently recorded. At the time of writing there is a fairly large spot near the central meridian.

THE MOON:—

			Phases.	H. M.
May	4	☽	First Quarter	7 26 A.M.
,,	11	○	Full Moon	1 18 P.M.
,,	19	☾	Last Quarter	3 18 P.M.
,,	26	●	New Moon	10 50 P.M.

The moon is in perigee on the 1st and 28th, and in apogee on the 16th.

The following are the two principal occultations visible at Greenwich during the month:—

Date.	Star Name.	Magnitude.	Disappearance.			Reappearance.			Moon's Age.
			Mean Time.	Angle from N. Point.	Angle from Vertex.	Mean Time.	Angle from N. Point.	Angle from Vertex.	
			h. m.	°	°	h. m.	°	°	d. h.
May 2	68 Geminorum	5·0	7 25 P.M.	86	54	8 27 P.M.	301	263	5 6
,, 12	χ Ophiuchi	5·0	8 7 P.M.	129	166	9 5 P.M.	257	290	15 7

There are several "near approaches" during the month, notably that to λ Geminorum on the 29th at 9.5 P.M., the star just escaping occultation.

THE PLANETS.—Mercury is well placed for observation during the evenings of the early part of the month. The *greatest elongation* of 21° 31′ E takes place on the 10th, when at sunset the planet is fairly high up in Taurus, being then $2\frac{1}{4}$ hours above the horizon. Near the time of greatest elongation the planet precedes Venus by about an hour, so that with the help of the demarcation of the ecliptic by the line joining Venus and the sun it should not be difficult to locate the position of Mercury.

Venus is the most prominent object in the western sky after sunset, and cannot fail to attract the attention by her brilliancy. On the 1st she sets at 10.46 P.M., and on the 31st at 11.19 P.M. The apparent diameter of the planet is increasing, being 15″·0 at the middle of the month; also the phase is becoming prominently gibbous, 0·74 of the disc being illuminated. On the evenings of the 20th and 21st the planet will be close to the star ε Geminorum, and on the evening of the 29th she will be in proximity to the moon.

Mars is an evening star in Virgo, and is available for observation throughout the month from sunset until after midnight, setting on the 1st at 3.41 A.M., and on the 31st at 1.39 A.M. There is no mistaking the planet, since he is the brightest object in the sky looking southwards, and also on account of his ruddy colour. The bright star Arcturus has a somewhat similar appearance, but it is not so bright, and further has a greater altitude. With small telescopes one sees the disc and that there are markings, but it is difficult to delineate them; also the polar snow cap is not showing to advantage. About the middle of the month the diameter of the planet is 12″·0, whilst 0·926 of the disc is illuminated. He is near the moon on the evening of the 7th, and ends his retrograde motion in Virgo on the 11th.

Jupiter and Saturn both rise after midnight. Near the middle of the month the former rises about 2 A.M., and the latter about 1 A.M.

Uranus is in Ophiuchus, rising on the 1st at 11.13 P.M., and on the 31st at 9.10 P.M. On account of his extreme southerly declination, however, he is not favourable for observation this month at convenient times.

Neptune is only available for observation during the earlier parts of the month. On the 19th he is very close to η Geminorum, having the same R.A. as the star, and being only 0° 9′ to the south; in fact during the whole month he will appear in the same field of view as the star if not too high a power be used. A few observations, therefore, will detect him on account of his changing position.

THE STARS.—About 10 P.M. at the middle of the month Ursa Major will be nearly overhead; Arcturus a little east of south, and Spica Virginis on the meridian; Leo in the south-west, and Gemini in the north-west; Cygnus in the north-east; Vega high up in the east; Scorpio rising in the south-east.

Chess Column.

By C. D. LOCOCK, B.A.

Communications for this column should be addressed to C. D. LOCOCK, Netherfield, Camberley, and be posted by the 10th of each month.

Solutions of April Problems—(By C. D. Locock).

No. 1.

1. R to R5, and mates next move.

No. 2.

1. Q to Kt4, and mates next move.

SOLUTIONS received from "Alpha," 2, 0; W. Nash, 2, 2; G. A. Forde (Major), 2, 2; "Looker-on," 2, 2; A. H. H. (Croydon), 2, 2; W. H. S. M., 2, 2; G. W. Middleton, 2, 2; "Tamen," 2, 0; "Quidam," 2, 2; J. W. Dixon, 2, 2; H. F. Culmer, 2, 2; T. Dale, 2, 2; A. H. Doubleday, 2, 2; W. J. Lawson, 0, 2; C. Johnston, 2, 2.

G. Heathcote and H. F. W. Lane.—Many thanks for your letters.

J. W. Dixon.—Glad to hear that you appreciate the prize problems.

A. Lillie, J. C. Candy, P. G. L. F., H. N. Fellows.—Thanks for the problems, which I shall hope to publish in the course of the year.

Hamilton White.—I am afraid that I cannot be drawn by your counter-proposal that I should send you the solution of your own end-game. In stating that Black's moves were not all forced, I erroneously put "Black" for "White," Black being the usual defending side in problems and end-games for publication. You will see, of course, that *White's* 4th, 5th and 6th moves are not forced. The promotion to a Knight may be a little unusual in actual play, but I consider, nevertheless, that the whole *modus operandi* is a little too obvious, in spite of the testimony of well-known players in its favour.

G. A. Forde (Major).—Yes, the solution of No. 2 last month was inaccurately given.

Alpha.—I discarded No. 2 many years ago on account of the second solution by 1. Q to Q7; but the Black Pawn at Kt2 now prevents this.

W. J. Lawson.—If 1. B to Q3, P × Kt.

"*Tamen.*"—Please see reply to "Alpha" above.

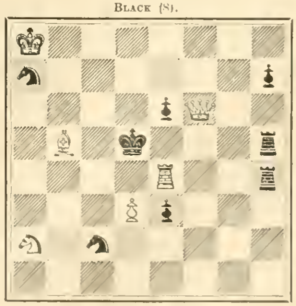
W. Jay.—I much regret that your solutions this month were too late. The issuing post-mark is "1 P.M., April 11."

PROBLEMS.

No. 1.

By W. Geary.

BLACK (8).



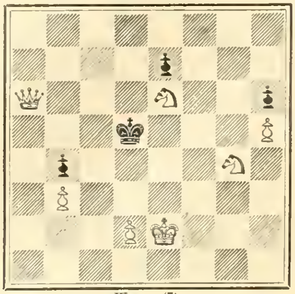
WHITE (6).

White mates in two moves.

No. 2.

By T. Geary.

BLACK (4)



WHITE (7)

White mates in three moves.

CHESS INTELLIGENCE.

The Inter-University Match took place on March 23rd, the scene of play, after the lapse of many years, being once more the St. George's Chess Club. The result was a rather decisive victory for Cambridge. Mr. Pillsbury officiated as adjudicator, and the score was:—

CAMBRIDGE.		OXFORD.	
H. A. Webb, Trinity ...	1	H. F. Davidson, Exeter ...	0
H. Bateman, Trinity ...	1	H. D. Roome, Merton .	0
B. G. Brown, Trinity ...	½	T. H. Bumpas, St. John's ..	½
G. Leatham, St. John's ...	0	W. M. Grundy, All Souls' ..	1
D. Glavert, Clare ...	1	H. Taylor, Balliol	0
L. H. Goh, Emmanuel ...	1	S. C. von Ernsthausen, Balliol	0
T. Lodge, Trinity	1	S. N. Foster, Worcester ...	0
	5½		1½

On March 27th and 28th, Oxford and Cambridge combined forces to play their fifth match by cable against the American Universities. The result depended on Mr. Pillsbury's adjudication on the game at the last board, and the award of this game to the English team gave them the victory. Score:—

OXFORD & CAMBRIDGE.		AMERICAN UNIVERSITIES.	
H. A Webb (Camb.)	½	C. T. Rice (Harvard) . .	½
H. Bateman (Camb.)	0	F. H. Sewell (Columbia) ..	1
H. F. Davidson (Oxf.)	1	J. F Sawin (Yale)... ...	0
H. D. Roome (Oxf.)	0	— Richardson (Princetown)	1
T. H. Bumpas (Oxf.)	1	H. A. Keeler (Columbia) ...	0
B. Goulding-Brown (Camb.)	1	— Bridgeman (Harvard) ...	0
	3½		2½

The Anglo-American cable match for the Newnes Challenge Cup was played on April 3rd and 4th. Messrs. Pillsbury and Marshall, being in London at the time, played their games over the board, as last year, and against the same opponents. The result in Mr. Pillsbury's case was again a drawn game against Mr. T. F. Lawrence, the City of London champion, but Mr. Marshall took his revenge on Mr. Atkins. Mr. Blackburne played in his most ingenious style against Mr. Barry, but eventually succumbed under great pressure of the time limit. Mr. Mills drew with Mr. Hodges, as everyone predicted. It does not speak well for the improvement of English chess, that the two players new to the team were players of such long standing as Messrs. Gunston and Hooke. The former of these, a very sound player, and an expert in correspondence games, certainly justified his inclusion. The Americans retained possession of the trophy; should they do the same next year it will become theirs finally. The score was as under:—

ENGLAND.		AMERICA.	
T. F. Lawrence	½	H. N. Pillsbury	½
J. H. Blackburne ...	0	J. F. Barry	1
D. Y. Mills	½	A. B. Hodges	½
H. E. Atkins ...	0	F. J. Marshall	1
G. E. Bellingham	1	E. Hymes	0
H. W. Trenchard	0	H. Voight	1
R. P. Michell	1	C. J. Newman	0
Herbert Jacobs	½	E. Delmar	½
W. H. Gunston	1	C. Howell	0
G. A. Hooke	0	H. Helms	1
	4½		5½

At Monte Carlo, last month, Dr. Tarrasch, of Nuremburg, won his sixth international tournament, and this in spite of the fact that he scored only 2½ out of his first six games. Nowadays, owing to want of practice, he is always a bad starter, but he gradually recovers all his old form, and in a long contest like that under notice he is sure to be near the top. For a long time Messrs. Pillsbury and Teichmann held the lead, but ultimately lost their places, and were passed by Maroczy. In the absence of Lasker, Janowski, and Tchigorin, the tournament was, of course, not quite representative of international strength, but there seems to have been only one really weak player. The final score was:—First Prize, Dr. S. Tarrasch, 20; Second Prize, G. Maroczy, 19; Third Prize, H. N. Pillsbury, 18½; C. Schlechter, 17; R. Teichmann, 16½; G. Marco, 15½; F. Wolf, 14; J. Mieses, 13; F. J. Marshall, 12; J. Mason and S. Taubenhaus, 10½; A. Albin, 8; Reggio, 7½; Col. Moreau, 0.

Yet another international tourney begins at Vienna on the 1st of this month, the "King's Gambit accepted" being compulsory in every game.

Brighton Society announces a three-move problem tournament in connection with *Das Neue Illustrirte Blatt*, the idea being to ascertain what kind of problem will best fall in with the widely differing views of English and Continental judges. Mr. B. G. Laws will be the English judge. Entries from Great Britain should reach Mr. Max J. Meyer (Chess-Editor of *Brighton Society*), St. Charles, Percy Road, Bournemouth, not later than May 31st.

Mr. H. N. Fellows, of 74, Curzon Street, Wolverhampton, has issued a short and clearly-written pamphlet, reprinted from the *Wolverhampton Journal*, on the art of solving three-move chess problems. The price of the leaflet, which is intended for beginners, is 2d. post free.

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CONTENTS.

MAN'S PLACE IN THE UNIVERSE.

By Camille Flammarion.

The problems which the eminent naturalist, Russel Wallace, has just brought under discussion are certainly among those which may well engage the attention of thinkers, no matter to what school of philosophy they belong. It would take too long to examine them in detail, but we can, in a glance, easily take account of the weakness and fragility of the foundation upon which he seeks to raise his new anthropocentric theory.

The fundamental astronomical thesis of the author may be thus summarized: The number of the stars is not infinite; the entire universe is represented by the agglomeration of stars, of which the Milky Way marks the principal plane; our sun is in the centre of the universe.

We may at once grant that the number of the stars is not infinite. Besides, there are here two contradictory terms. Any *number* whatever cannot be infinite. On the contrary, we can easily imagine to ourselves another star placed here or there, or two stars, or ten, or a hundred. But the infinite is that to which nothing can be added.

But it is of consequence that we should not confound the stars with space. Space cannot be otherwise than infinite. It is boundless, illimitable. If we imagine any confine to it whatever, immediately we pass in thought beyond it. Doubtless we could criticise even the definition of space Some philosophers, and those by no means minor ones, have defined space as that which separates two bodies in such a manner that without matter there would be no space. On the other hand, theologians refuse to admit the infinity of space, so as not to give to it an attribute of God. They maintain that space is finite, and assert that beyond its limits there is nothing. I venture to think that here there is a mere sophism. If matter did not exist there would still be space, that is to say, a place* in which we might imagine matter to exist.

One of the most curious arguments which Dr. Wallace urges against the "infinite number" of the stars is, that if it were so, there would be stars everywhere over the entire sky, without any empty space, and since that every star is a sun, all these contiguous points of light should form a dazzling sphere, whose brightness should equal that of the sun. This objection to the infinitude of the stars was the subject of long and learned discussions during the course of the 18th century and up to the middle of the 19th. It would not be difficult to settle it to-day.

In the first place there is nothing to prove that the light of the stars does not suffer a diminution greater than the square of the distance, owing to the imperfect transparency of the cosmical medium. Space is not empty. Why may not the ether exercise any absorption on the luminous rays?

In the second place, why think only of the bright stars, of the incandescent suns? And the dead suns? May not as many or more dark stars exist as bright ones? Might not the milliards of dark stars interpose between us and the most distant luminous ones?

In the third place there is nebulous matter. Space is full of it; photography has discovered it everywhere. Why should nebulous matter be necessarily luminous? Originally it may have been obscure.

In the fourth place we may not neglect the cosmical dust to which we owe the Zodiacal Light (a reflection of the solar light), the shooting stars, which the earth encounters by hundreds of milliards in a year, as well as other interstellar phenomena to which it gives rise.

The agglomeration of stars of which our sun forms one is not infinite, it is limited; it is very heterogeneous, as we see it, composed of thousands of clusters of stars of diverse densities, and scattered at diverse distances. The immensity which encompasses it is relatively void, and our sidereal universe is composed of but a determinable number of stars.

It is this stellar agglomeration which Dr. Wallace considers as representing the entire universe, a position which has not been proved. Moreover, in this agglomeration he considers the sun as being central and preponderant. Let us see if it is so.

We are within the Milky Way, since this encloses us under the form of a great circle, but we are neither exactly in its medial plane, nor exactly at its centre. Moreover, the Milky Way is not a uniform and organised sidereal

* Some object that this is tautological. Not so. But we make use of words for speaking and writing. Our conception of space is bound up closely with our sense of touch, our muscular sense. Our ideas are derived from our impressions undoubtedly. But we must not confuse the relative with the absolute unknowable to us in its essence. The exterior world is not conditioned by our sense of it. Without us the Sun, Sirius, and space would exist.

system of which our sun is a preponderating star. The Milky Way is made up of an agglomeration of clusters of stars disposed pretty nearly in the same fairly wide plane.

The telescope has disclosed a great number of clusters of stars and of nebulæ—about six thousand. But if we place on a chart, representing the two celestial hemispheres, these clusters and nebulæ, a fact is made clear worthy of the greatest attention. It is that most of the clusters are gathered into the plane of the Milky Way, and that most of the gaseous nebulæ are collected, on the contrary, away from this plane, and near the poles of the Milky Way.

This has a significance ot great importance to our knowledge of the structure of the sidereal universe.

On the other hand, if we examine the law of distribution of stars in the sky, we ascertain that their numbers gradually increase—for all magnitudes—in proportion as we approach the Galaxy.

But it is of consequence to note that neither for stars nor for stellar clusters is this condensation uniform. It is not, for example, by zones parallel to the Milky Way that we must proceed, for that method is insufficient, but by the direct examination of the sky. If we trace isophotic charts giving the sidereal density as is done on hypsometrical charts for contour relief, these differences are made evident.

On a clear summer night, our eyes, trained astronomically, can observe in this vast celestial girdle of the Galaxy very different stellar densities, and we gain the impression that far from being a regular system, comparable to the solar system, for instance, the Milky Way is a perspective image formed by the superposition of an innumerable multitude of stellar clouds, scattered over immense distances in one chief plane. We see it divided into two unequal branches in Cygnus and the Scorpion, and rent here and there into numberless stars.

Our sun is no more at the centre than his neighbour Alpha Centauri (which lies about forty-one trillions of kilometres from us) or than our other neighbour 61 Cygni (about sixty-nine trillions distant)—both right in the plane of the Milky Way—or than the majority of the stars whose parallaxes have been measured. These stars are distant from us several light-years, whilst the limits of the Galaxy are situated at thousands of light-years.

Not only does our sun not mark the centre of our universe more than our neighbours in space do, but it has no greater weight than they. Alpha Centauri is a splendid binary system and its mass is more than twice the sun's. We do not know what planets may circulate round one or other of these two stars, whose mutual revolution is nearly a century. It is not surprising that we cannot see them, since if our sun were at their distance Jupiter would be a star of the 24th magnitude, separated by 4″ from the sun, which would itself be of but the second rank. Seen from the distance of stars of the 1st magnitude, themselves very diverse, our sun would appear but of the third, fourth, fifth or sixth rank, and might be even invisible from Rigel or Canopus, which have no measurable parallax. The mass of Sirius is equal to that of four suns. Vega is seventy times as bright, and Canopus surpasses the sun in brightness by more than ten thousand times. Dr. Wallace's theory might be excusable for an inhabitant of the systems of Sirius or Capella or Antares, but not for a dweller in our own modest hamlet. If there were a central sun, and if that central sun were ours, the illusion might be granted. But there is nothing of the kind. The solar system is a monarchy with the sun for autocrat Our sidereal universe is a republic, a federation without a dominating authority.

According to the calculation of Lord Kelvin, the amount of the proper motions of the stars indicates that the number of the suns of our sidereal universe does not seem to exceed one thousand millions. The force of gravitation of these suns, taken in the mean to be similar to our own, would produce the velocities observed of twenty to one hundred kilometres per second. A number ten times greater could only have been deduced if those movements were much more rapid. Granted this milliard of stars, it in no wise proves that it alone exists in the infinite, and that beyond an immense void there may not be a second milliard, nor a third, nor a fourth, nor more. Whatever may be its extension, our Milky Way is but a point in the infinite.

It would even now appear that we know of stars which do not belong to our sidereal system. We might cite with Newcomb, the star 1830, Groombridge, the swiftest of those whose motion has been determined, its speed exceeding 300,000 metres per second. The attractive force of the milliard of stars of which we have just spoken would not appear sufficient (except under special circumstances) to produce such a velocity, and many astronomers think that this star has come from the beyond, and traverses our universe like a projectile. This star is not the only one in such a case.

On the other hand, certain *globular clusters* do not seem to form a part of our agglomeration.

This agglomeration represents a universe. It approximates, in spite of its heterogeneity, to the general form of a flattened spheroid, of which the Milky Way marks the equator. Facts seem to indicate that the forces which influenced its evolution exercised their greatest intensity and activity in its equatorial zone rather than at the circumpolar regions, which have remained backward, less dense in actual stars or in those in the making, colder, and, so to speak, benumbed. Everything is more advanced in the equatorial region than at the poles. Our sun itself appears to be in its summer. There red stars are crowded, and there also are temporary resurrections.

On the whole, then, the astronomical theory of the distinguished naturalist has not been established, and, in fact, is quite inadmissible. It would be superfluous, therefore, to occupy ourselves with its biological consequences relative to our planet, the assumed object of the creation. In our solar system, this little earth has not obtained any special privileges from Nature, and it is strange to wish to confine life within the circle of terrestrial chemistry. Nor is it less so to see a naturalist (whose theories of evolution demand the action of time as the principal factor in the succession of species) forgetting that the epoch in which we now happen to be has no special importance; that the different worlds of our solar family are at different stages of their evolution; and that, for instance, if the Moon is a waif of the past, Jupiter, on the contrary, is a world of the future. The effect of the hypothesis of Dr. Wallace is to narrow our horizon, and to take us back again to the time of Ptolemy, into the prison of a useless firmament. The greatness of modern astronomy, on the contrary, is to burst all barriers, for our science is but a shadow in the face of the reality. Infinity encompasses us on all sides, life asserts itself, universal and eternal, our existence is but a fleeting moment, the vibration of an atom in a ray of the sun, and our planet is but an island floating in the celestial archipelago, to which no thought will ever place any bounds. Never lose sight of the fact that space is infinite, that there is in the void neither height, nor depth, nor right nor left; and in time neither beginning nor end. We must understand that our conceptions are relative to our imperfect and transitory impressions, and that the only reality is the Absolute.

What right have we then to suppose that the limits of our knowledge are the limits of the power of Nature?

Every day we have proofs to the contrary. If we examine into the conditions of life, it would not be difficult to conclude that terrestrial chemistry does not necessarily include the universal vital circle. To limit the work of Nature to the sphere of our knowledge is to reason with singular childishness. Of old, our fathers considered the four elements "earth, air, fire, water" as the principles of all, and saw in them the conditions of life. How many solemn dissertations have been written on this subject? To-day we affirm the necessity of carbon for the constitution of living organisms. But no one knows what carbon is. Our successors will, no doubt, smile at our assertions, and, doubtless, the inhabitants of the systems of Rigel, and of Deneb—stars characterised by the rays of titanium and silicon—would understand nothing of the necessity for carbon.

The careful study of our planet shows that the forces of Nature have Life as their supreme end.

Yes, life is universal, and eternal, for time is one of its factors. Yesterday the moon, to-day the earth, to-morrow Jupiter. In space there are both cradles and tombs. The red carbon stars will soon be dead; the hydrogen stars like Vega and Sirius are the stars of the future; Procyon, Capella, Arcturus, are the stars of the present. Aldebaran seems to be already an autumn fruit. Let us open the eyes of our understanding, and let us look beyond ourselves in the infinite expanse at life and intelligence in all its degrees in endless evolution.

THE PALÆONTOLOGICAL CASE FOR EVOLUTION.

By R. Lydekker.

(Continued from page 102.)

Dismissing thus briefly a very interesting portion of our subject, we proceed to bring to the reader's notice some of the most important lines of mammalian descent which have been worked out on palæontological evidence. The most famous and most widely known of these is the horse series, which has been so frequently described in full detail that a very short notice will suffice here. Starting with the little hyracothere of the London Clay—a short-limbed and short-necked ungulate of the approximate size of a fox, with short-crowned cheek-teeth, the socket of the eye completely open, the bones of the lower part of the leg (radius and ulna in front, and tibia and fibula behind) separate, and four front and three hind toes—an almost complete passage can be traced through the extinct three-toed horse-like ungulates of the middle and upper portions of the Tertiary period to the single-toed horses, asses, and zebras of the present day. The modifications include a great increase in bodily size, the lengthening of the crowns of the cheek-teeth coupled with a marked increase in the complexity of their structure, the enclosure of the socket of the eye by a bony ring, the degeneration of the ulna and fibula and the fusion of their upper portions with the radius and tibia respectively, the early loss of the fourth front toe, and the gradual reduction in the size and length of the lateral toes of the tridactyle members of the series, till they are represented in the modern horses only by the so-called splint-bones attached to the sides of the upper half of the cannon-bone of the greatly enlarged middle digit. The five-toed ancestor of the little hyracothere is not yet definitely known, but it was probably not far removed from the phenacodus of the lower Eocene. The similarity between the form of the skull of the little hyracothere and that of the modern horse is most remarkable, and is well shown in a series of models recently added to the collection in the Natural History Museum. So far as human eye can see, the horse has practically reached the supreme stage of evolution, so far as its skeleton is concerned, of which its organisation is capable; the only improvement that suggests itself being the total abolition of the useless splint-bones, which are apt to be a cause of disease. Not the least curious feature in this remarkable series is its repetition in the North American strata; a repetition which has given rise to the suggestion that the modern horses have had a dual origin, one branch developing in the Old World and a second in the New. On the whole, however, it seems more probable that the line of development, which took place when the Eastern and Western hemispheres were much more closely connected by way of Bering Strait than at present, was single. It may be added that the ancestral horses, such as the hyracothere, were closely allied to the lophiodons and palæotheres of the Tertiary, which in their turn lead on towards the tapirs and rhinoceros, so that all the earlier odd-toed ungulates were more or less nearly related.

A most remarkable instance of a line of development parallel to that of the horse series is presented by certain South American Tertiary ungulates belonging to an extinct subordinal group allied to the perissodactyles or existing odd-toed forms. In the most generalised representative (*Theosodon*) of the group in question the feet were three-toed, with the lateral digits functional and of about the same relative size as in the modern tapirs. In the next form, *Proterotherium*, the lateral toes have become much smaller and shorter in proportion to the large central one, and no longer touched the ground in walking. Finally, in *Thoatherium*, according to the Argentine palæontologists, only the single median digit remains in each foot; even the splint-bones having disappeared in the hind-limb, although minute vestiges of their upper extremities persist in the fore-foot. If the restoration be correct, *Thoatherium* was therefore an even more specialised animal in regard to foot-structure than the modern horses. The two lines of evolution presented respectively by the horses and the proterotheres form, perhaps, the most remarkable instance of parallel development with which we are yet acquainted. A somewhat curious, and at present inexplicable, difference in regard to the development of the terminal joints of the toes is, however, noticeable in the two series. In the earlier members of the horse series this segment is comparatively narrow and displays a median cleft, but in the later forms the bone widens and the cleft disappears. Precisely the reverse of this occurs in the proterothere series, the terminal bone of each digit being broad and entire in the earliest form, and narrow and cleft in the latest.

The proterotheres are, however, by no means the only extinct South American ungulates displaying evidence of progressive development. In some of the latest Tertiary deposits of the country—probably belonging to the human period—Darwin discovered certain more or less fragmentary remains of an ungulate with the general proportions and size of the modern camels. Subsequent discoveries showed that the macrauchenia, as it is called, presents the unique peculiarity that the nasal chamber opens in the centre of the forehead, instead of at the extremity of skull. Allied but much smaller animals from the earlier Tertiary strata of Patagonia exhibit a gradual transition from the macrauchenia in regard to the position of the external aperture of the nose-cavity towards the normal mammalian type. And since they likewise show a transition in respect of dental characters, which are very aberrant in macrauchenia, that extraordinary creature is brought into line with less aberrant members of the ungulate order.

In the tapirs and rhinoceroses specialisation has not

been carried to anything like the same degree as in the horse tribe; and has been to a great extent restricted to an increasing complexity in the structure of the cheek-teeth, coupled, in the second of the two groups, with a reduction in the number of the anterior teeth and the development of one or two horns in the middle line of the skull. Nevertheless, in both groups American palæontologists have been able to trace a more or less complete line of descent. The tapirs, for instance, appear to have originated from a small Eocene ungulate known as systemodon, which comes so close to the early ancestors of the horse, that it was at one time included in the same series. Modern rhinoceroses, in which, as we have said, the number of front-teeth is more or less reduced, can likewise be traced back to early Tertiary ancestors without horns, but with a full series of teeth.

Among the even-toed ungulates, or those in which the toes are symmetrically arranged on each side of a line running between the third and fourth of the typical series of five, one of the most complete lines of descent has been traced out in the camel tribe, now represented only by the true camels of the Old World, and the llamas of South America. The evolution of this group seems to have taken place in North America in the middle Tertiary period, in the strata of which we meet with an ancestral form in poëbrotherium—an animal of the size and proportions of a small gazelle, but with all the essential characteristics of a camel, although with a fuller series of teeth, and feet in which the main bones are not fused into a "cannon-bone" and traces of the lateral digits still remain. Earlier members of the group show still more primitive characters, and it is probable, although not quite certain, that these in their turn pass into yet more generalised animals, with four complete toes to the feet, and cheek-teeth in which the crowns are surmounted by simple low cusps instead of forming the tall crescents found in camels and llamas.

Precisely similar differences, both as regards foot-structure and tooth-structure, distinguish the true ruminants (deer, antelopes, etc.) from the pig-like animals. And yet a complete gradation from the former to the ancestors of the latter can be found, although it would perhaps be difficult to construct the actual pedigree. In like manner from the tallest and largest-antlered members of the deer tribe a gradual passage can be traced to the small and hornless dremotherium of the middle Tertiary, from which it is but a step to the still smaller and more primitive gelocus – not improbably the common ancestor of both deer and chevrotains. Giraffes, again, partly with the assistance of that marvellous creature the okapi, are now known to be connected with ruminants of a much more ordinary type.

Till quite recently the elephants and mastodons, forming, with the imperfectly known dinothere, the proboscidea of zoologists, constituted an altogether isolated group whose relationship with other ungulates was quite obscure. The wonderful discoveries of Messrs. Andrews and Beadnell in the lower Tertiary deposits of the Egyptian desert have, however, brought to light the remains of two remarkable animals which, as regards both bodily size and the structure, number and mode of succession of their teeth, serve to connect the modern proboscideans very closely indeed with the more generalised extinct ungulates. Nor is this by any means all, for there appear to be indications of affinity between these primitive Egyptian proboscideans and the ancestors of the modern sea-cows (dugongs and manatis). This is, however, a subject on which little can be said at present, for the evidence is not yet published, and the writer is consequently not at liberty to mention even such facts as he knows. When fuller investigations have been made into African palæontology it is probable that not only will the puzzle of the origin of the proboscidea be completely solved, but their ancestral relation to the sea-cows will likewise become an established fact.

Reverting once more to the carnivora, it will be remembered that the ancestral types of the modern forms are to be found in the extinct creodonts; and it is probable that from the latter a direct line of descent can be traced through various extinct forms to the civets and mongooses of the present day. Till the above-mentioned discovery of mammalian remains in the French phosphorites no carnivora were considered more widely sundered than the civets and mongooses on the one hand and the weasels and their allies on the other; the structure of the hinder part of the base of the skull being very different in the two. Now, however, we are acquainted with quite a number of small mammals from the phosphorites which completely bridge the gap between the groups in question. Since the base of the skull has the same general structure in both, the bears were long regarded as near relatives of the weasel tribe, so that both were classified in a single group, to the exclusion of civets and dogs. Palæontology has, however, revealed the existence of an absolutely complete transition, both as regards dental and foot characters, from dogs to bears. Consequently, not only are we compelled to regard the latter as the descendants of primitive dog-like animals, but the similarity of their skulls to those of the weasel tribe must be looked upon as an instance of parallelism in development and not as an indication of genetic affinity.

Possibly the chain of relationships does not stop even with the affinity of bears to dogs, for the former appear to be intimately related to the sea-bears and sea-lions, although, unfortunately, there is no palæontological evidence at present available to confirm or disprove the presumed relationship.

If there be a real connection between the bear-like land carnivores and the sea-bears, it is almost certain that the typical earless seals must have taken origin from a totally different group of carnivores. And it has been suggested that the typical earless seals may be derived directly from creodonts related to the form described under the name of patriofelis. Since, however, we cannot trace seals further back than the later portion of the Tertiary period, additional palæontological evidence must be awaited before anything definite can be said with regard to their ancestry.

Neither is the ancestry of whales by any means definitely known, although there are some indications of the line of descent of the group represented by the sperm whale and dolphins. The late Sir W. H. Flower was indeed disposed to regard whales as the descendants of early hoofed mammals, but there was no definite evidence in support of his contention, and the probability is that they are related to the early carnivores. In modern whales all the teeth have the same simple conical form, but in the middle Tertiaries occur the shark-toothed dolphins, or squalodons, in which the front teeth differ markedly in character from those of the cheek series, the latter being serrated and implanted by double roots. Still more generalised is the earlier and much larger zeuglodon, in which the cheek-teeth are not unlike those of certain seals. So far as it goes, then, the palæontological evidence tends to connect the modern toothed whales with the carnivora, and it certainly traces their descent from animals departing much less widely from the more ordinary mammalian type. It may be added that certain living porpoises show a few rows of bony tubercles in the neighbourhood of the back-fin, similar tubercles occurring in a more developed condition in some of their extinct relatives. Now with the remains of zeuglodon are frequently discovered a number of bony plates, which there is accordingly strong reason to believe

belonged to that animal. If that be the case, the ancient cetaceans were mail-clad animals, and on that supposition the bony tubercles of the aforesaid porpoises must be the remnants of such a coat of mail. A wonderful instance of inheritance, if only it be true.

Very isolated among living mammals are the anteaters, sloths, and armadillos of Central and South America, collectively constituting the typical representatives of the order Edentata; and until quite recently palæontology gave no clue as to their ancestry. All the living members of the group are characterised by the absence of front teeth (the anteaters, in correlation with the nature of their food, being alone absolutely toothless); and their cheek-teeth are of simple structure, alike in form, and devoid of the hard enamel coating of less aberrant mammals. The Tertiary deposits of Patagonia have, indeed, yielded the remains of an armadillo furnished with a full series of enamel-coated teeth; but this, although a step in the right direction, does not go far in affiliating the group to other mammals. In the lower Tertiaries of North America there have, however, been discovered the remains of a group of extinct mammals—the so-called ganodonts—which there is every reason to believe were the ancestors of the modern edentates. These ganodonts have in some instances a full series of differentiated and enamel-clad teeth, and their skulls and limb-bones show a remarkable resemblance to those extinct South American edentates known as ground-sloths. Moreover, many of the later forms display a tendency to a reduction in the number of the front teeth, and to a partial or complete loss of the enamel of those of the cheek series. On the other hand, the earlier members of the group show evident signs of affinity to the contemporary creodonts and ancestral ungulates. In regard to their resemblances to the typical edentates, Dr. Wortman* writes as follows: "If this astonishing array of similarities is accidental, and does not indicate genetic affinity, then all that can be said is that palæontological evidence is worthless in the determination of the various successive steps in the descent of a group or species. I hold that, in view of all the evidence above set forth, the preposition that the one has descended from the other may now be regarded as a positively demonstrated fact."

As isolated at the present day as the edentates are the rodents, or gnawing mammals, as exemplified by the rat, the porcupine, the hare, &c. In all these animals the single large pair of chisel-like incisor-teeth in the front of each jaw grow throughout life, and thus never develop roots; while they are separated by a long gap (uninterrupted by a tusk, or canine) from the teeth of the cheek series, which never exceed four pairs in each jaw, and are all alike. A further peculiarity of the group is the backward and forward movement of the lower jaw during mastication, as may be seen by watching a tame rabbit feed. Till recently nothing definite has been known with regard to the ancestry of the group; but a short time ago Professor Osborn pointed out that mixodectes and certain other small mammalian types from the lower Eocene strata of North America presented just such characters as might naturally be looked for among ancestral rodents; and he proposed to regard them as forming a primitive section of that group under the name of Proglires. They differ from modern rodents by possessing a full series of rooted incisor and canine teeth, not separated by a well-marked gap from the cheek series, and the absence of a backwards and forwards motion of the lower jaw.

An approximation to the modern rodent type is, however, exhibited among certain members of this extinct group by the tendency to the enlargement of the second pair of incisors in each jaw (corresponding to the single large pair of modern rodents), accompanied by the degeneration of the other two pairs of those teeth and the canines. And from these and other structural features there seems considerable probability that the position assigned to the group by Professor Osborn indicates their real affinities. If so, the modern rodents are closely connected with less aberrant mammals.

Finally, we came to the Primates, which includes two well-defined and sharply distinguished groups, one containing man, apes, and monkeys, and the other the much less highly organized creatures commonly known as lemurs or lemuroids. Widely sundered as are these two subgroups at the present day, there existed in Madagascar, even so late as the human period, a creature which, although evidently a lemur, exhibits certain monkey-characters. When, however, we descend to the basal strata of the Tertiary period—the Lower Eocene—we meet, both in Europe and North America, with a number of small mammals which are certainly referable to the Primates, but exhibit characters tending on the one hand to connect that group with other primitive mammals, and on the other hand apparently to show an intimate relationship between the ancestors of the modern anthropoids (man and monkeys) and lemuroids. With regard to these early forerunners of the highest of all mammals, Professor Osborn observes that three suppositions are possible:—"First, that these Primates represent an ancient and generalised group ancestral to both Lemuroidea and Anthropoidea; second, that they include representatives of both Lemuroidea and Anthropoidea, contemporaneous and intermingled; third, that they belong exclusively to one or the other order." Whichever of these suppositions be nearest to the truth, it is evident that in Eocene times the Primates were represented by a number of exceedingly generalised forms presenting much the same relationship to the modern specialised monkeys and lemurs as the primitive creodonts bear to modern carnivores and the condylarthrous ungulates to existing hoofed mammals. Further, these primitive Primates were themselves not far removed from the ancestral carnivores and ungulates.

In conclusion, as the result of the foregoing extremely sketchy summary, it is quite clear that since the publication of the first edition of the "Origin of Species" palæontological investigations and discoveries have shown that most of the main primary groups of vertebrates on the one hand and of the different orders and families of mammals on the other are respectively connected, as we recede in time, by such a number of intermediate links and gradations that the gaps are now comparatively few and far between. And what is true with regard to mammals is likewise true to a greater or lesser degree in the case of reptiles and fishes.

Gaps, and in some cases large ones, undoubtedly still remain; but in no single instance has any fact been recorded with regard to the past history of vertebrates which militates in the slightest degree against the theory of evolution. On the contrary, everything points to a continuous and orderly succession of forms of life gradually progressing from the primitive and generalised to the modern and specialised types.

The only rational explanation of such a regularly progressive series—especially when the existence of vestigial structures, like the splint-bones of the horse, in certain forms is taken into consideration that presents itself to the unprejudiced judgment is evolution, and we venture to think that Dr. Wortman is fully justified in his assertion that this may be regarded, from the palæontological aspect alone, as a fully demonstrated fact.

* *Bull. Amer. Museum*, Vol. IX., p. 104 (1897).

Whether, however, evolution is the result of "natural selection," or any other form of what I take leave to call blind chance, is a totally different question, although one upon which I do not, on the present occasion, intend to enter.

THE ROTATIONS OF THE SUN, JUPITER, AND THE EARTH, AND THEIR EFFECTS.

By Mrs. Walter Maunder.

In her latest and most valuable work, "Problems in Astrophysics," Miss Clerke says: "The two fundamental problems connected with the nature of the sun are its rotation and its periodicity. They may be quite closely allied, and in regard to both, 'counsels of despair' have begun to prevail. The spot-cycle, like 'Carrington's law,' is set down as a congenital peculiarity, and the mists of the past are invoked to cover the perplexities of the present. . . . Explanatory hypotheses avail little, but the sifting of facts avail much." Elsewhere, when dealing with the "Structure and movements of sunspots," she writes: "Isolated observations are rarely of any considerable value in such complex matters. Meaning accrues to them just in proportion as they can be allied to others made in correspondence with them, but under modified conditions. 'Correlate and compare' should be the watchword of astrophysicists." In the following correlation and comparison I do not wish to suggest any explanatory hypothesis whatsoever. I merely place in juxtaposition observations of some phenomena that appear to be directly or indirectly allied.

Again quoting from Miss Clerke, "Little progress has been made towards ascertaining the cause of solar periodicity. We are only assured that it is not imposed from without, but arises from within; it resembles a 'free' rather than a 'forced vibration.' This conclusion, it is true, tends to relegate the matter to obscurity, for the interior of the sun is a *terra incognita*, and seems likely to remain so. His cyclical changes may belong to his original constitution; they may date from nebular times, and be as inherent as the tone of a bell. Or they may simply characterise a stage of growth, and prove liable to modification and effacement." If the cause of the solar changes is to be sought from the influence of something external—of a planet or of several planets, for instance—then sooner or later, the period, or the intermingled periods, must come unravelled. If the primary cause lies within the solar photosphere, then it may well be that the question is one that our earthly experience may never enable us to answer; to even guess at the true answer. Or the hidden processes may be modified by external influences, so that we may be able to measure the method and extent of these influences, and obtain an imperfect solution of the problem

In sheer ignorance we are obliged to postulate conduction and convection as the means of conveying heat from the interior of the sun to his photosphere for radiation. The processes of conduction proceed slowly; therefore it is assumed that the sun is "a globe riddled with convection currents of which the shining cloud-shell of the photosphere constitutes the limit." But convection is impeded by viscosity, and this must increase as the temperature and pressure together increase in the lower depths of the sun. There must come a limit where convection currents will cease to flow, and we cannot agree with Miss Clerke that Dr. Wilsing and Prof. Sampson are wrong in limiting "convective circulation within the solar globe to a relatively thin shell of material." In the deeper layers there must be some other methods of transmitting thermal energy. In the "American Journal of Science" for 1902, Prof. Frank Very advocated the theory that under the transcendental conditions of the sun's interior, heat is evolved with explosive energy by the *destruction of matter*. This can, however, scarcely be accepted as a working hypothesis in a science that takes as its basis of argument the conservation of energy and the conservation of matter.

The condition of the sun's interior must prevail also in Jupiter, though in a minor key. Here we have a state of things that bears directly on the question of the solar surface markings, of their periodicity, and of their connection with rotation. In January of the present year, Prof. G. W. Hough published in "Science," N.S., Vol. XVII., No. 420, the results of his study of the planet since 1879, and on this paper I base the facts and figures hereafter given.

It must be remembered that objects are very rarely seen beyond 40° of Jovian latitude. The latitude of 70° is only 1″ from the limb, and hence markings if they exist in such a high latitude are practically invisible to us. Observations of Jupiter's surface are therefore almost entirely confined to the eighty degrees that enclose his equator. Within this region the markings consist of "white" spots, "dark" spots, and belts, all of which are disposed very approximately along parallels of latitude.

Many of these markings have a great degree of permanence. The most famous, the Great Red Spot, has been identified with a great red spot observed by Hooke and Cassini in 1664-6; it was then situated one-third of the semi-diameter of the planet south of the equator in about latitude 19°. It appeared and vanished eight times between the years 1665 and 1708, when it was invisible until the year 1713. It became conspicuous in 1878, since when it has been always visible, though at times so faint as to be lost in small telescopes. This Jovian spot differs from its solar analogues in the degree of its permanence. Like them, it is not stationary in either longitude or latitude, and a further similarity is that its proper motion in longitude is much greater than its proper motion in latitude. It has drifted in longitude about three and one-fourth times around the planet since 1879; its total displacement in latitude has been 1″·7, or about 4000 miles. Its rotation period is not uniformly regular. From observations of Gledhill and Mayer, in 1869 and 1870, its period appeared to be 9h. 55m. 25·8s.; in 1879, Prof. Hough found it 9h. 55m. 33·7s.; in 1898-9, 9h. 55m. 41·7s.; and in 1902, 9h. 55m. 39·7s. Prof. Hough is inclined to connect its visibility with its rotation period.

Prof. Hough differs from most other Jovian observers in concluding that the rotation period of a spot does not depend on its Jovian latitude. He cites the instance of two white spots situated in latitude 6° south, which, from 1879 to 1885, gave a rotation period of 9h. 50m., the equatorial belt giving at the same time a period of 9h. 55m. The period 9h. 50m. is, indeed, more commonly found between the limits −8° and +11°, whereas the longer period is distributed indiscriminately over the surface of the whole planet as far as 38 degrees latitude. The difference of rotation between two near-lying markings he attributes to the difference in their levels. We thus seem to find an analogy to the different rotations given by faculæ and spots, but none to "Carrington's law of zones,"—the different rotations given by spots in different latitudes.

Prof. Hough concludes his paper by saying: "It seems to be the opinion of most writers on Jovian phenomena that the planet is yet at a high temperature, but not self-luminous. The high temperature is favourable for the explanation of some of the phenomena observed. . . .

The greater luminosity of the centre of the disk indicates absorption of light, probably due to an extensive atmosphere. . . . I (Prof. Hough) assume that the visible boundary has a density of about one-half that of water. This medium is in the nature of a liquid; in it are located the Great Red Spot and the egg-shaped white spots. In such a medium, all motions in longitude and latitude would be slow and gradual, and the shape and size of the object would have great permanency. . . . The great bay in the south edge of the equatorial belt may be accounted for by assuming that the great red spot is at a lower temperature than the medium in which it floats, and by its lower temperature condensing a portion of the vapour composing the belt. . . . In 1883 I stated that the spot seemed to have a repelling influence on the belt."

If the action of the sun is largely instrumental in causing the phenomena of Jupiter's spots and belts, then any periodicity due to revolution round the sun should recur every twelve years. There is no such cycle conspicuous, and any slight periodicity due to this cause—either in the forms or the rotations of the markings—has escaped notice if it exists. Jupiter has also a fairly large family of his own, but we cannot lay to the account of his satellites the credit of originating his disturbances any more than we can attribute to the planets, the spots, faculæ, and prominences on the sun. But in both cases there may be a modifying influence—a Jovian observer of the very first rank has told me that in his transits of the Great Red Spot during the last years, he has detected a period, corresponding to a conjunction of the two largest satellites—a swing or vibration in the Spot as the satellites pulled on it this way or that.

Here, then, on Jupiter we seem to get some analogy to the sun. The planet is itself at a high temperature, but is scarcely at all self-luminous; its photosphere, if it may be so termed, is of the nature of a liquid; and its maculæ have increased and become more permanent as its radiative output decreased.

In a yet minor degree still, the condition of things prevailing in the sun must also prevail in the interior of the earth. From the solid crust, radiation is *nil*; in the centre the pressure and temperature must be such as have no name.

In the year 1600 Dr. William Gilbert wrote that the "earth is a great magnet"; that its "magnetic virtue" comes from within the earth, and not from the heavens above. This was an inspiration on his part rather than a valid deduction from facts at his disposal, and it was not until the nineteenth century that it was shown that only about five per cent. of the earth's magnetic force is to be referred to electric currents, either circulating round the earth or passing to and fro between the earth and the air. The remainder is derived partly from permanently magnetised substances in the earth's crust, but chiefly from a system of electric currents embedded deep in the interior of the earth and connected with the earth's rotation. The diurnal variations, annual variations (not secular change), and magnetic perturbations are to be ascribed to electric currents in the upper regions; and it is these which vary in intensity with the sunspot cycle. But for the rest there are, I think, three points to be noted. First, in the "Magnetic Declination Tables and Isogonic Charts for 1902,' Mr. L. A. Bauer states that, 'according to the researches of two Russians, Leyst and Passalskij, the diurnal variation is different over locally disturbed areas, *e.g.*, in regions of iron mines, from what it would be if the disturbances did not exist. . . . . Whether the secular change is likewise different over locally disturbed regions from what it would be if the local disturbance were not present, is not yet known." Next, magnetic storms are most frequent and violent during the periods of sunspot activity, and are in very many instances coincident with the passage of a disturbed region across the central meridian of the sun. During the prevalence of these storms, according to Mr. Bauer, strongly marked variations in the electric currents within the earth's crust manifest themselves along with the variations of the magnetic needle. And, thirdly, it may be a mere coincidence, but it seems a significant one, that the commencement of the prolonged sunspot minimum in the seventeenth century synchronized with the vanishing of the magnetic declination. It would not be wise to press this coincidence too far, seeing that we cannot be certain when the long solar calm really commenced. It was marked and commented upon from 1660 onwards. Neither have we frequent observations of the magnetic declination, nor at many places, and the time at which it disappeared is not the same for all the places of observation. But, taken in conjunction with each other, these three phenomena suggest that the deep-seated magnetism of the earth is not wholly unaffected by the solar changes, and the study of its variation may show evidence of change in the sun.

The chief source of the earth's magnetism is due to a system of electric currents in its interior, and connected in some manner with its rotation. It is believed that the secular change of the earth's magnetism is to be referred primarily to the effect of secondary electric currents generated within the earth by its rotation around an axis not coincident with its magnetic axis. The diurnal variation is taken as due to a system of currents in the earth's upper atmosphere, which are connected with the earth's rotation, in that different parts of its surface are exposed to the action of the sun's rays in a period of twenty-four hours. The variation itself varies in sympathy with several solar phenomena, and is thereby seen to be influenced, directly or indirectly, by the sun's rotation. The solar phenomena which change concurrently with the diurnal variation of the earth's magnetic force are, the corona, the prominences (eruptive and quiescent), faculæ and spots.

The variation of sunspots, both in number, area, and distribution during the progress of the solar cycle, is too well known to need much detailed description. Briefly, at maxima, the spot-zones occupy mean positions in about 15° of N. and S. latitude; as the minima approach, the zones sink and die out near the equator; and about the same time a new series of spot-zones have come into existence in high solar latitudes, and gradually with the advancing cycle approach again the maximum position at about 15° N. and S. There is thus indicated an intimate relation between the intensity of the whole solar disturbance and its distribution in solar latitude. But the individual spots and streams of spots show a closer connection still with the rotation of the sun on his axis. A stream of spots is, or always tends to become, parallel to the sun's equator. Where there is comparatively large initial inclination, the "pull" is so strong that I have noticed a slight swing across the line of latitude before the stream settled down to steady parallelism. So too with a single spot whose umbra was oval, and inclined to the equator.

Spots are rarely seen in higher latitudes than 30°; never I believe above 50°. Faculæ, like spots, wax and wane with the solar cycle, but have two zones of maximum activity in each hemisphere. Their principal maxima are displaced with the spot-zones; secondary maxima occur in high latitudes beyond the regions frequented by spots. They are only distinguishable near the sun's limb, where the greater absorption of photospheric light by the sun's "dusky veil" throws them into bright relief. They are, however, closely connected with, if not actually identical—

in position at least—with the "calcium faculæ" photographed by Prof. Hale over the solar disc by means of a double slit. The monochromatic photographs show that these "calcium faculæ" lie in a series of belts also along parallels of latitude. I have not heard whether a series of such photographs—first taken by Prof. Hale towards the beginning of the last maximum—have been made in anything like a continuous manner during the decrease of solar activity, and the minimum which has just passed. If so, it would be interesting to know whether these bands move or alter in amount as the solar activity decreases and increases again.

Eruptive prominences are exclusively found in the sunspot belts. Quiescent prominences have their maximum within 15° of the poles when the sun is most disturbed, and as his activity decreases they move downward and crowd more or less closely round the equator. Since we observe both only when on the sun's limb, we cannot say whether they are disposed in parallel belts or not. The corona seems to follow closely the law of distribution obeyed by the quiescent prominences, but its forms are certainly greatly disturbed and modified by the presence of eruptive prominences. Thus in the corona of 1901, whilst the streamers on the western limb presented the featureless symmetry of dead minimum, the streamers on the eastern limb were moulded and distorted by underlying disturbances, strongly suggesting that the type of corona seen during any eclipse is not due so much to the period reached in the cycle of solar activity as to the actual disturbance of the sun at the very time.

But when the sun is actually quiescent then the undisturbed, we might almost say the normal, form of the corona consists of two pairs of wings folded symmetrically about and parallel to the sun's equator. So that it is evident that the corona, whether or not it partakes of the sun's motion round an axis, is influenced by the sun's rotation; it owes its form to this motion when not disturbed by other—for it more powerful—influences.

There are only three bodies whose rotation effects we can study. The first is the sun, a gaseous body, intensely hot, and intensely luminous, rotating on its axis once in 25 days; we can study the corona, the calcium faculæ and the spots, all influenced in a more or less marked degree by the sun's rotation. We can study the planet Jupiter, a body whose outer shell is probably liquid, still hot, but not luminous to any degree, its spots and belts are distributed in a marked manner along parallels of latitudes; and its rotation is accomplished once in about ten hours. We are on the earth, a body with a solid crust, rotating once in 24 hours, and we can study the systems of electric currents from which the earth's total magnetism chiefly results.

THE CHEMISTRY OF THE STARS.

III.—STARS OF THE SECOND TYPE.

By A. FOWLER, F.R.A.S.

NOTWITHSTANDING the great multitude of lines exhibited by the spectra of stars of the second type, the task of investigating their chemical significance is in some respects easier, and often more certain in its results, than that which has to be faced in dealing with stars of other types. This is because of the very close resemblance between this type of star and the sun, so that whatever may be learned from the spectrum of the sun by making use of more powerful instruments than can be employed in the case of stars, may be confidently assumed to be true of those stars which resemble the sun in so far as their spectra can be compared.

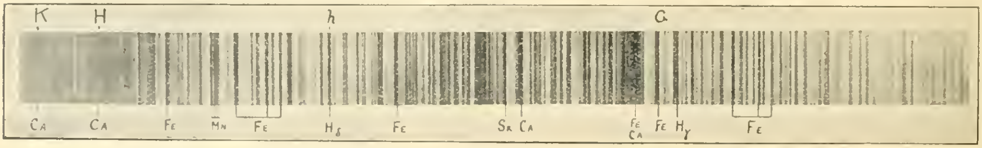


FIG. 7.—Photographic Spectrum of Arcturus, showing chemical origins of some of the principal lines.

[Reproduced by kind permission of Sir Norman Lockyer.]

Of the stars included in the second type, the two chief varieties are typified by Arcturus and Aldebaran; or, adopting the nomenclature of Lockyer, it may be said that the second type comprises the *Arcturian* and *Aldebarian* stars. In both varieties the same lines are present, but in the Arcturian stars the hydrogen lines are relatively stronger than in the Aldebarian, while the reverse is the case with the other lines. On account of the predominance of metallic lines in their spectra, both varieties are conveniently grouped together by Lockyer as "metallic stars." Fig. 7, from a photograph taken at the Solar

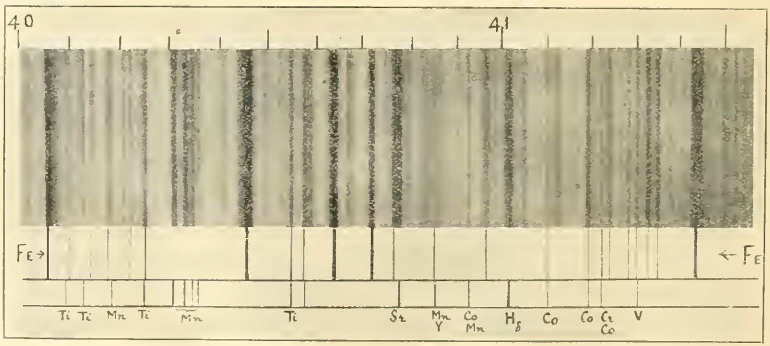


FIG. 8.—A small part of the Spectrum of Arcturus, showing chemical origins of some of the principal lines. (The scale indicates wave-lengths.)

Physics Observatory, South Kensington, gives an excellent idea of the Arcturian type of spectrum, with its numerous well-defined lines. When the spectrum is carefully dissected, it is found that it reproduces the solar spectrum with remarkable fidelity, even in minute details. In Fig. 8 we have an enlarged view of the small part of the spectrum between wave-length 4000 and wave-length 4150, which should be compared with the photographs of the same part of the solar spectrum previously given in Figs. 2 and 3 (Knowledge, February, 1903). Comparing it with the solar spectrum photographed with moderate dispersion (Fig. 2), the similarity is especially manifest, and the stellar spectrum only differs from the more perfect photograph of the solar spectrum shown in Fig. 3 in compounding groups of close lines into single lines. There is no reason to suppose, however, that such groups would fail to show the separate components if instruments of sufficient dispersion could be employed on the stars.

It is evident then that the sun is the best example of the Arcturian group of stars, and that an interpretation of its spectrum will also hold good for the other stars of the same type. As already explained, this interpretation is based on matching the solar lines with lines of terrestrial substances, preferably by photographic methods, and it is then found that most of the lines correspond in wave-length and relative intensity with those which appear in the *arc* spectra of various metals. The results of such comparisons are best exhibited by tabulation of wave-lengths, and the accompanying brief extract from Rowland's great table of something over twenty thousand solar lines will indicate the nature of the results obtained by the use of instruments of very great dispersion.

(The table should be compared with Figures 2, 3, and 8.)

Wave-length.	Substance.	Intensity.	Wave-length.	Substance.	Intensity.
4043·956	Ti	0	4046·230		2
4044·056	Fe	3	·490		00
·141		2	·612	Cr	0
·294	K	0	·764		000
·423		000	·917		0
·531		00	4047·171		00
·644	Zr	1	·338	K	00
·766	Fe	3	·461	Ce—Fe	2
·992		000	·556		00
4045·108		000	·823	Y	0
·266	Mn	2	·958		0
·371	Ce, Mn	1	4048·224	Cr	1
·538	Co	5	·384		00
·662		0	·549		00
·748	Zr, W?	2	·704		00
·864		0	·818	Zr	1
·975	Fe	30	·910	Mn—Cr	5
4046·117		1	4049·148	Mn	0

It will be observed that many of the lines, chiefly of small intensity (as indicated by the intensity numbers, 0, 00, 000), have not yet been identified, but, as the possible comparisons are by no means exhausted, it is not yet to be concluded that such lines have no terrestrial equivalents. The elements so far recognized as contributing to the solar spectrum in its entirety are as follow:—

Aluminium.	Iron.	Scandium.
Barium.	Lanthanum.	Silicon.
Cadmium.	Magnesium.	Silver.
Calcium.	Manganese.	Sodium.
Carbon.	Molybdenum.	Strontium.
Cerium.	Neodymium.	Titanium.
Cobalt.	Nickel.	Vanadium.
Copper.	Oxygen.	Yttrium.
Chromium.	Palladium.	Zinc.
Hydrogen.	Potassium.	Zirconium.

In addition there is evidence which suggests the possible presence of the following elements:—

Beryllium.	Lead.	Ruthenium.
Didymium.	Lithium.	Tantalum.
Erbium.	Mercury.	Thallium.
Germanium.	Niobium.	Thorium.
Glucinum.	Osmium.	Tin.
Indium.	Platinum.	Tungsten.
Iridium.	Rhodium.	Uranium.

Besides these, though not revealing their presence in the Fraunhofer spectrum of dark lines, helium and the hypothetical "coronium" are important constituents of the solar chromosphere and corona respectively, and there can be little doubt that indications of these gases would also be found in the Arcturian stars if we were near enough to disentangle the spectra of the separate parts of the stars, as we are able to do in the case of the sun. This example forcibly illustrates the important truth that the investigation of such a spectrum as that of an Arcturian star can only directly reveal the chemical composition of the particular part of the star which by its absorption produces the dark lines. The spectrum indicates what is certainly present, but gives no evidence as to what is really absent.

The general result of this analysis of the solar spectrum then is to show that the elements entering into the composition of stars of the second type are not essentially different from those composing the earth, and this obviously is a conclusion of the first importance in considerations relating to the plan of the universe. Its significance can be partially realised when the number and distribution of the stars are investigated. There is already evidence that some thousands of stars have spectra of the second type, but dealing only with those which have been studied in detail, Lockyer finds that out of 470 stars* (including all the stars down to magnitude 3·5 in both hemispheres) there are 78 of the Arcturian and 56 of the Aldebarian group; that is, in more than a quarter of the stars investigated there is direct evidence of the predominance of solar and terrestrial matter. It is indeed not too much to say that not only are the same substances present in all these stars, but that they exist in the same proportions throughout.

A study of the distribution of stars of this type is not less suggestive. Some of the brighter members, according to Lockyer, are as follow:—

Aldebarian Stars.	Arcturian Stars.
γ Andromedæ.	α Aquarii.
γ Aquilæ.	α Arietis.
β Capricorni.	α Aurigæ.
α Hydræ.	α Boötis.
ε Pegasi.	α^1, α^2 Capricorni.
α Phœnicis.	α Cassiopeiæ.
α Serpentis.	α Centauri.
α Tauri.	β Geminorum.
α Toucani.	γ Leonis.
β Ursæ Minoris.	γ Persei.
ε Virginis.	β Virginis.

These few examples will serve to show that the second type stars surround us in every direction, and a further consideration of their distances, so far as they have been ascertained, suffice at least to show the immensity of the space through which terrestrial matter is dispersed. Recently published determinations by Elkin give the parallax of α Tauri as 0″·109, of α Aurigæ as 0″·079, of β Geminorum as 0″·056, and of α Boötis as 0″·026, corresponding respectively to 30, 41, 59, and 125 light-years. Taking proper motion as an indication of stellar distance, the

* "Catalogue of 470 of the Brighter Stars, classified according to their chemistry at the Solar Physics Observatory." (H.M. Stationery Office. 1902.)

researches of Kapteyn suggest that there is a preponderance of metallic stars among the stars nearest to us, but at the same time there are many stars of this class which have no appreciable proper motion, and are therefore presumably among the stars most remote. It may therefore be concluded that matter similar to that composing the sun is distributed throughout the visible universe.

THE SUNSPOTS OF 1903, MARCH AND APRIL.

By E. Walter Maunder, F.R.A.S.

The year 1901 was, beyond question, the year of the solar minimum. But the evidences of reviving activity were curiously slow to manifest themselves. There was, indeed, a slight upward progression in 1902, the mean daily spotted area being nearly double what it had been in the previous year. But the intervals during which the solar disk remained absolutely quiescent were numerous and long, so that whereas 81 per cent. of the days in 1901 showed no spots, 72 per cent. in 1902 were in a like case. From 1902, June 5, to September 17, a period of fifteen weeks, there was practically unbroken quiescence; only two or three minute spots—and these faint and short-lived—were seen during the whole time. But with September 18 a more active period began, and the next ten weeks showed more spot groups than the whole of the year beside. December was a quiet month, but new

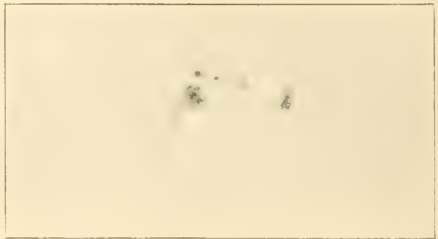
Group A, 1903, March 26.

spots were seen with the commencement of the new year, and the sun showed a slight but steady activity up to March 21.

On this day a distinctly new phase commenced. A large regular spot, which for distinctness of reference we will call A, appeared on the east limb, in north latitude 24°. Two days later another group appeared, likewise at the east limb and in the same latitude. This second group, B, consisted of a small stream of rather unstable spots. On March 26th a third group, C, appeared also on the east limb. This spot was larger than its predecessors, but was apparently in a later stage of development. The areas covered by these three groups, if expressed in the unit adopted at the Royal Observatory, Greenwich, "millionths of the sun's visible hemisphere," would be about 200, 100, and 260. The Greenwich unit corresponds to a little more than a million square miles, so that the areas expressed as millions of square miles would be approximately 240, 120, and 300.

These areas are, of course, quite small compared with those which are presented to us at the time of the solar maximum. Thus on 1893, August 7th, the total area covered by all the spots visible on that day amounted to 6000 millions of square miles; that is to say, an area nine times as great as that presented by the combination of these three groups. Indeed, one of the groups of the minimum year, 1901, was as large as these three groups put together; yet the sun has been so quiet for so long that considerable attention has been attracted by them, not merely in scientific quarters but also in the daily press.

By April 3rd, the first group, A, had passed off at the west limb; the second group, B, which had disappeared for a while and then formed afresh on a somewhat larger



Group C, 1903, March 31.

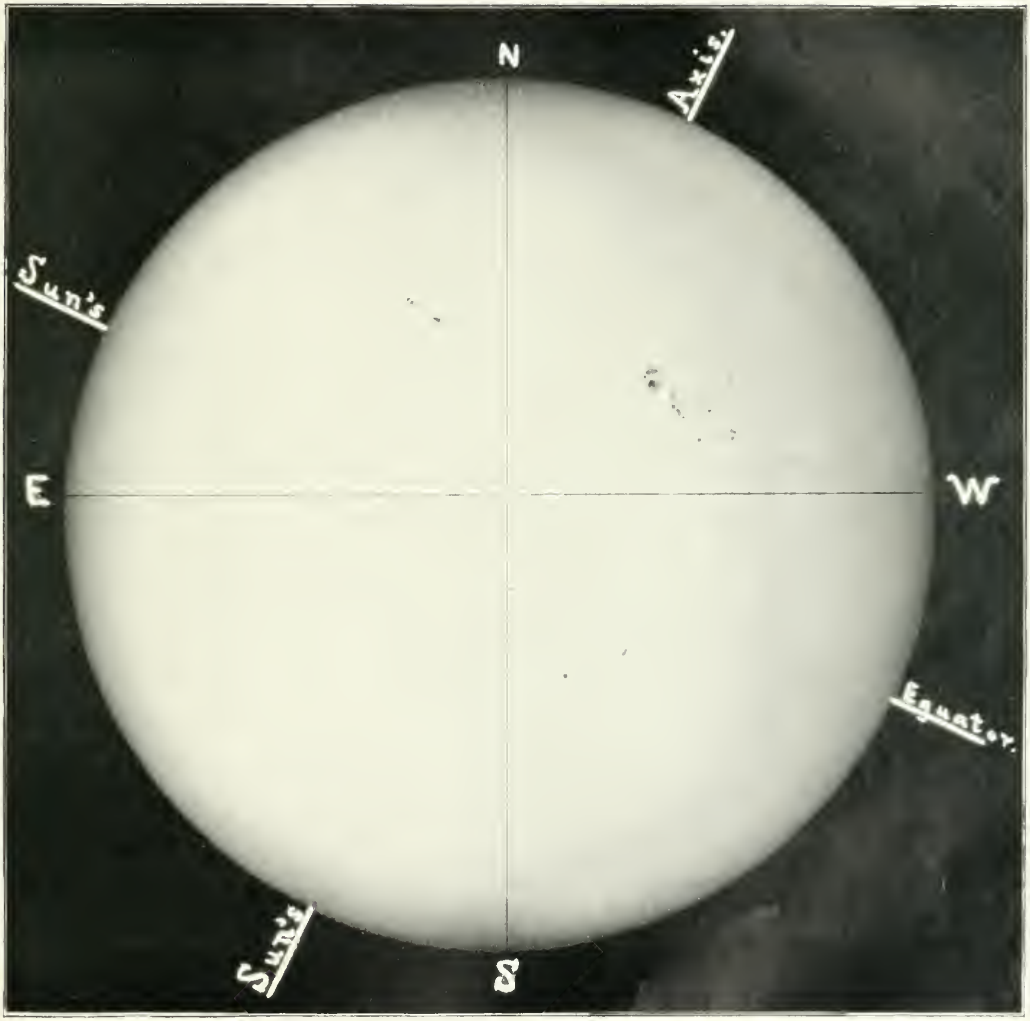
scale, was approaching the west limb; and the third, C, which was in latitude 17° S., had broken up and greatly diminished, and only two small faint spots remained. As if to compensate for this diminution, a fourth group, D, appeared on this day on the east limb in the same latitude, or nearly so, as group C. Group D was larger than any of its predecessors, and was fairly regular in shape, with a fringe of small spots bordering it on the following side. Its area was about 420 millions of square miles.

A particular interest attached to this group D, in that when it had advanced rather more than halfway towards the central meridian there was a sharply marked little magnetic disturbance, which may or may not have been connected with it. It is certainly not one of the instances

Group D, 1903, April 6.

in which the connection between sunspot and magnetic disturbance is unmistakable, but it deserves note as an instance of *possible* connection.

On April 8th, a small stream of faint spots, E, appeared on the east limb in latitude 22° N. On April 19th, two groups, both small, appeared on the east limb, the one a return of the spot A of March 21st, and the other, F, almost balancing it in the southern hemisphere. That is to say, the two spots had nearly the same longitude, but their latitudes were of opposite signs. Spot C of March 26th returned on April 22nd. On April 24th a new group

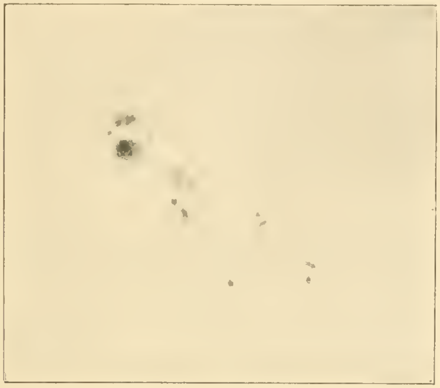


PHOTOGRAPH OF THE SUN;

1903, April 30d. 11h. 11m. 51s., G. Civil Time.

Taken at the Royal Observatory, Greenwich, with the Thompson Photoheliograph of 9 inches aperture.

appeared at the east limb in latitude 18° N., and was followed three days later by another, H, in the same latitude. On April 30th, when the photograph was taken which forms our plate, and which we owe to the kind permission of the Astronomer Royal, these three groups were all fully displayed near the centre of the disc. The



Group G, 1903, April 30.

two northern groups, G and H, were both streams of sunspots, the larger of which, G,—first seen on the limb on April 24th—now stretched out to a total length of over 100,000 miles. Usually in a stream of sunspots the leading spot is the best defined, and, if not the largest in the group, is only surpassed by the rear spot. If the stream, as is not uncommon, spreads out into two or three branches, inclined to one another at a small angle, they nearly always radiate from the leading spot. In the present instance the reverse is the case.

It is a curious circumstance, well worth attention, that all these eight groups took their rise in the hemisphere remote from the earth. All were first seen as the rotation of the sun brought them into view at the east limb. Group B had, alone of the eight, been seen during an earlier rotation, but like the others it formed in the unseen hemisphere and came into view at the east limb, where it was first seen, a regular spot, on February 23.

Letters.

[The Editors do not hold themselves responsible for the opinions or statements of correspondents.]

MAN'S PLACE IN THE UNIVERSE.

TO THE EDITORS OF KNOWLEDGE.

SIRS,—Dr. Wallace's conclusion is a very old one, almost obsolete. The Earth and man are in his view the centre, the end, and the supreme purpose of the whole universe, and every world and star are in existence for the production and the development of the living soul of man.

This theory, that of all antique religions, has seemed so completely overthrown by the discoveries of science that nobody has dared to defend it. Is the new astronomy coming back after a long digression to the supreme conclusion of the ancient learning? Is the universe a purely anthropocentric thing? We do not believe it, and without following our author to theological ground (we are very incompetent for that) we hope to present some arguments against the views he so firmly advances.

In the first place, from that strictly scientific point of view which is ours, is it correct to say that the Earth is, in the solar system, a planet peculiar in its habitability? To discuss that fully, it would be necessary to expound at length the doctrine of the plurality of inhabited worlds, a doctrine well known by the works of Flammarion, Gore, and many other gifted authors. We prefer to rest on the grounds adopted by Dr. Wallace, and to admit with him that for sustaining life (we ought to say *life such as we know it on earth*) some elementary substances are requisite, and also a temperature restrained between narrow limits during the long sequence of the ages necessary for the evolution of living beings.

According to Dr. Wallace, the conditions of life are:—

1st.—A distance from the Sun sufficient, and just sufficient, to produce clouds, rains, and river-circulation, and to keep up the temperature required. We are of the same opinion, but it seems to us that such a circulation and such a temperature are possible on other planets than the Earth. The spectroscope reveals unmistakable aqueous vapour in the atmospheres of at least Venus and Jupiter. In the general plan of the solar system, the distance from the Sun to the Earth is not peculiar or extraordinary in any way.

2nd.—A sufficient atmosphere to produce the said water-circulation, and to equalise the burning heat of the days and the frozen coldness of the nights. Is this equalisation a property exclusively given to our orb? Are the atmospheres of Venus and Jupiter defective for that office? Dr. Wallace writes also: "The mass of an atmosphere depends largely upon the mass of the planet; Mars is, therefore, unsuitable for life." Is not this in every way a purely gratuitous assumption?

3rd.—A large proportion of the planetary surface covered by oceans, with currents and tides. Tidal action being dependent upon the Moon, the want of such a satellite prevents Venus from having high forms of life. The author forgets that the Sun is able to produce very appreciable tides by itself, especially in the case of Venus, to which it is nearer than to our Earth. And on our Earth, to look at the question from another side, tideless seas (as the Mediterranean Sea) are by no means lifeless.

4th.—The depth of oceans, indicating the permanency of their features. We grant it, but upon what grounds can we assert that such a depth is wanting on other planets?

5th.—The existence of atmospheric dust, produced by deserts and volcanoes, as this is the first cause of rain and clouds. Granted, but volcanoes can exist on other worlds. From this point of view the Moon would be an ideal orb. It is a very curious way of proving that life exists only upon our Earth to say that deserts are peculiar to it. For if there are no deserts on other planets there must be their opposites, viz., a luxuriant vegetation and innumerable forms of life. Anyway, shooting stars and meteorites might supply quite sufficient dust to produce water-condensation.

Such are the arguments by which Mr. Wallace sustains his idea that the conditions of life do not co-exist on other planets than our Earth. We believe very firmly that they are absolutely insufficient for any scientist. We believe, on the contrary, from an impartial study of all the scientific data, that life is possible on other worlds, and that the Earth has not the privilege of being the unique inhabited and inhabitable orb.

We are also unable to accept another view of Dr. Wallace, namely, that on the confines of the universe (supposing it finite) the law of gravitation is not obeyed,

and radiant energy becomes so irregular that life cannot exist. These are pure assumptions, without any scientific ground to sustain them. On the contrary, we see the law of gravitation ruling over the most distant double star systems. We need more than an assumption to overthrow a doctrine so plausible as that of the plurality of inhabited worlds.

To leave these secondary questions and to examine the problem itself. Dr. Wallace asserts that, on the authority of the new astronomy, the Sun occupies a special and unique situation, being at the very centre of the universe. Do the astronomical results justify that very important conclusion?

The scientific basis upon which Dr. Wallace mainly, if not entirely relies, is that of the invaluable book by Prof. Newcomb, "The Stars: a Study of the Universe." We fear Dr. Wallace did not read this book with sufficient care, for we have just read again that masterly work, and we are by no means led to such a conclusion as that reached by Dr. Wallace.

In the first place we are confronted by the question, "Is the universe finite or infinite?" An insoluble problem in the present state of science. With Newcomb, Dr. Wallace says: "The universe, or, at least, the visible universe seems finite," and he follows the arguments of Prof. Newcomb completely. We believe, personally, that no convincing proof has been brought out against the universe being infinite; but, for brevity, we will grant that the visible universe is a limited body. We will also even grant that our solar system lies in the medial plane of the Milky Way (from the fact that the Galaxy is seen on the Heavens as nearly a great circle, which it would not be if we viewed it from a side of the central plane). But this is all; and we are unable to say with Dr. Wallace that the sun is placed *exactly* at the centre of the Galactic ring. In fact, no such a definite conclusion is warranted except by evidence which is not yet before us.

If we grant, however, that the sun is in the *neighbourhood* of the central plane of the Milky Way, does it follow that we are in the centre of the Galactic universe? It would do so, according to our author; and to put his theory on firm ground, Dr. Wallace again refers to the researches of Prof. Newcomb and Kapteyn (of Gröningen). From their marvellous studies, so clearly set forth by Newcomb in "The Stars," the nearer stars (nearness indicated not by their brilliancy, but by their mean proper motion) would form a sort of solar cluster, almost globular, and the Sun would be deeply immersed in that cluster. But if we suppose these results from somewhat hypothetical stellar statistics to be true, why should Dr. Wallace say our Sun is at the centre of that cluster and, therefore, at the centre of the whole universe?

We have ourselves studied the text of Newcomb's work, certainly the scientific base of Mr. Wallace's paper, and we were quite unable to find any sufficient arguments to establish this central position of our Sun. Prof. Newcomb writes (p. 312) on the nearness of the Sun to the central plane of the Galaxy. According to Dr. Wallace's theory, our luminary must be at the very centre of the Galaxy, otherwise it would lose immediately its unique situation. Even for Prof. Newcomb, it remains to be proved whether the Sun is or is not at the centre of the medial Galactic plane, some facts inducing him to think that we are nearer to one side of the Milky Way (in the constellation Aquila) than to the other. Further, if by hypothesis, at a given instant, the Sun were at the centre of the universe, it would lose its position soon, and never return to it again. We must not forget the proper motion of our luminary, a motion of ten miles per second at least. With that speed, how could the Sun rest for all eternity at the centre of the universe, as a king on his throne? We must not forget also that this solar motion is a relative one, deduced from the apparent opposite motion of the stars. This seems a clear proof that the sidereal universe does not remain concentric (so to speak) with the Sun.

We have, therefore, no right to claim for the Sun, the Earth, and man, a peculiar and privileged position. We must not indeed neglect on *à priori* grounds any theory, however startling and unexpected it may be, but we may respectfully invite the new theorist to submit his views to the cross-examination of science. We regret to say that we believe Dr. Wallace's ideas are not supported by the new astronomy. His paper is astonishing and, in a sense, interesting to read, but we very candidly declare ourselves not convinced by the reasons offered to us, and we remain impenitent adherents of the doctrine of the plurality of worlds; a doctrine so simple, so charming to the human mind, and so fertile in phitosophical deductions.

When we gaze on the heavens, we prefer to think that there are other lives and other humanities, than to place ourselves on a pedestal and to look proudly round an empty universe. We acknowledge, without hesitation, that this preference is no material proof of life on other worlds, but we beg in exchange to be allowed, without being considered guilty of contempt for the teachings of science, to regard the Sun and the Earth as very ordinary orbs, having no special characteristics, and as no more suitable for life than innumerable other suns and planets which rotate in the unknown infinite.

Marcel Moye.
Professor in the University of Montpellier (France).

5, rue Flaugergues,
Montpellier, France.

IS THE UNIVERSE LIMITED?

TO THE EDITORS OF KNOWLEDGE.

Sirs,—In a notice of Dr. A. R. Wallace's recent article by Professor W. H. Pickering, a view of the question of the limits of the universe is taken which I think will strike many of your readers as new, but seems to be borne out to a considerable extent by the Harvard observations on the stars in the constellation of Orion. It is that an infinite number of luminous stars is quite consistent with the limited quantity of light which we receive from the sky, provided that the distance between the stars becomes (on the average) greater the farther we go from the solar system. On the generally accepted scale, the light of a star of the n^{th} magnitude exceeds that of a star of the $n + 1^{th}$ magnitude in the proportion of 2·512 to 1. Now suppose the average distances of the stars in question to be in the ratio of 1·585 ($= \sqrt{2{\cdot}512}$) to 1, and that owing to the thinning out of the stars the number only increases in the ratio of 1·256 for each degree of magnitude. The total light of the stars of the $n + 1^{th}$ magnitude would then be only one-half of that of the stars of the n^{th} magnitude; and if the same process went on to infinity, the total light of all the stars fainter than the n^{th} magnitude would only be equal to that of stars of the n^{th} magnitude.

Taking the constellation of Orion, the increase in the number of stars for each magnitude has, according to the Harvard observations, come down to 1·4 or 1·3 to 1 before the stars become too faint for measurement. If this proportion continued to infinity the total light would be of very limited amount. The number of stars would indeed be infinite, for the number of the $n + 1^{th}$ magnitude would always exceed that of the n^{th}, but the total light given would diminish rapidly as n increased, and even if

the process went on to infinity could never exceed a very limited amount. It is, however, essential to this theory (assuming that no light is lost in transmission) that the thinning-out should go on to infinity. If it came to a stop anywhere we should arrive at a different result; and a thinning-out extending to infinity suggests that we are near the centre of the system.

I may add, however, that the constant detection of additional stars by more powerful instruments does not disprove the finiteness (in space) of the visible universe. We may be discovering fainter stars within the same space-limits as those already detected. There are still undiscovered stars (asteroids) within the limits of the solar system, and perhaps our nearest self-luminous neighbour has yet to be detected. Till lately we did not dream of the vicinity of Eros. On this subject (and many others) we must, I think, be content to wait and watch.

W. H. S. Monck.

[The point is not new. It was put forward very clearly by Mr. Charles E. Inglis in Knowledge, 1900, March, p. 65. It will be remarked that it assumes the proposition Dr. Wallace seeks to establish of the essentially central position of the solar system.—E. Walter Maunder.]

THE BIBLICAL "MAZZAROTH."

TO THE EDITORS OF KNOWLEDGE.

Sirs,—Can any of your readers tell me what star or constellation the word "Mazzaroth" means in the 38th chapter of Job and 32nd verse?

James B. Bower.

Claremont, Teignmouth, Devon.
24th March, 1903.

[There is an evident parallelism between Job ix. 9 and Job xxxviii. 32; and the "Mazzaroth" of the latter answers to "the chambers of the south" of the former. These are without doubt the twelve signs of the zodiac through which the sun passes in the course of the year. Each is brought out in its own "season," whilst the circumpolar constellation of the "Bear" (*see* the Revised Version) is always above the horizon, but is "guided" with her train in her unceasing circuit round the pole.—E. Walter Maunder.]

Notes.

Astronomical.—The interesting problem presented by the feeble nebulosity surrounding Nova Persei has been attacked in a most courageous manner by Mr. Perrine, of the Lick Observatory (Circular, No. 33). On account of its exceeding faintness, any attempt to determine the spectrum of this nebulosity seemed almost hopeless, but in view of the great importance of such knowledge, a photographic spectroscope of small dispersion was specially constructed for the purpose in connection with the Crossley reflector. Commencing with 7h. 40m. on the night of October 31st, 1902, and ending with 9h. 25m. on November 4th, a photographic plate was exposed to the spectrum of "condensation D," for no less than 34h. 9m., and it must have been very gratifying to find that the resulting negative showed even a very faint spectrum. A careful discussion of this photograph has led to the conclusion that the spectrum of the nebulosity in November, 1902, was not the spectrum of an ordinary gaseous nebula; that it was not the spectrum of the Nova since the latter became nebular; and that it more nearly resembled the spectrum of the Nova during the first few days of its outburst. This spectroscopic evidence is considered to be not inconsistent with the theory that the luminosity of the nebula is due to reflection of the light emitted by the Nova at the time of its greatest brightness, but it is not regarded as in itself quite sufficient to establish this theory.

Great activity on the part of the staff of the Lick Observatory is indicated by other circulars recently published. No. 29 gives particulars of measures of 117 new double stars, more than half of which have distances not exceeding one second. No. 30 gives observations, elements, and ephemeris of Comet a 1903 (Giacobini). No. 31 announces the variable velocity in the line of sight of ν Andromedæ, π^1 Orionis, σ Geminorum, and ι Argus; it is also noted that ϕ^2 Orionis has the great radial velocity of nearly 100 kilometres per second.

It has long been understood that spectroscopic determinations of the velocities of the components of a binary star, taken in conjunction with ordinary telescopic determinations of the orbit, would lead to a very exact knowledge of the parallax of such a system. This method of arriving at the parallax of a star has recently been successfully applied at the Lick Observatory to Delta Equulei (Circular 32), in which case the period is only 5·7 years, and the motion therefore relatively rapid. At the last periastron passage, about the middle of 1902, the relative velocity of the two components in the line of sight was found to be 20·5 miles per second, and the resulting value of the parallax is 0″·071. From this it results that the total mass is 1·89 times the sun's mass, and as the magnitudes are slightly unequal, the mass of the brighter star probably does not differ much from that of the sun. At periastron the distance of the components is about two astronomical units, and at apastron five of these units, the orbit being very eccentric. It is interesting to note further that, broadly speaking, the spectra of the stars are of the solar type.

It is interesting to learn that Nova Geminorum would not have escaped record even if it had not been discovered by Prof. Turner during its brighter stages. The nearly continuous photographs of the heavens made at the Harvard College Observatory indicate that while there was no star as bright as 9th magnitude in the position of the Nova on March 3rd, the Nova was about mag. 5 on March 6th, after which the brightness diminished. On a photograph taken on March 25th, the spectrum of the star is very conspicuous, showing several bright lines, which at once distinguish it from ordinary stars. By the end of March, transition to the nebular spectrum had already commenced.—A. F.

Botanical.—The remarkable *Davidia* which, until recently, has been known in Europe only from dried specimens, seems likely in the future to become a familiar plant in this country. It is a native of Central China, whither a collector was sent a few years ago by Messrs. Veitch, of London, for the special purpose of procuring its seeds. He has succeeded in this, and has brought home some additional information as to the peculiarities and distribution of the tree. The *Davidia* is a monotypic and somewhat anomalous genus of Cornaceæ. It reaches a height of thirty feet, and is not unlike our common lime tree in foliage. Its flowers are unattractive, but a striking effect is produced by the presence of a pair of very large white bracts just below every flower or flower-head. The mode of germination of the seeds is noteworthy. The fruits are ellipsoid, about an inch and a quarter long, the outer layer pulpy and the endocarp bony and grooved. It is indehiscent, but after lying several months in the

ground some pieces of the endocarp between the more prominent ridges fall out like miniature shutters, leaving as many apertures as there are cells and seeds in the fruit, and through these the radicle easily escapes. The tips of the cotyledons remain in the cavities of the fruit till the radicle has fixed itself to the soil, when they are completely withdrawn.

Monsieur Drake del Castillo has a paper in a recent number of the *Bulletin du Muséum d'Histoire Naturelle* (Paris) on the curious Didiereas, a genus of spiny trees from Southern Madagascar, which has hitherto not been satisfactorily assigned to any existing natural order. The late Dr. H. Baillon, who established the genus, placed it among the Sapindaceæ. Dr. Radlkofer, an eminent authority on this family, did not concur with Baillon, but thought that *Didierea* should constitute an independent order allied to Polygonaceæ and Amarantaceæ. It approaches the former in its fruit, pollen, and other characters, and recalls the latter in the structure of the embryo, and in having the anthers deeply cleft at the two extremities. It is pointed out, however, that *Didierea* has an anatropous ovule, whereas in Polygonaceæ it is orthotropous. Monsieur Drake del Castillo has made it the type of a new natural order, which he has called Didiereaceæ, admitting, also, another genus, *Alluaudia*, which is likewise a spiny tree from Madagascar.—S. A. S.

Zoological.—According to a very interesting and well illustrated article in the April number of the *National Geographic Magazine* (New York), by Mr. G. H. Grosvenor, the introduction of domesticated reindeer from Siberia into Alaska has turned out a thorough success. The Eskimo have proved themselves well-fitted to keep and train the animals: and it is hoped that in the near future the country will have large herds of these valuable ruminants. This will prevent the Eskimo becoming a burden to the revenues of the United States, as would otherwise have inevitably been the case owing to the diminution in the numbers of the whales, seals, walruses, bears, &c., which formerly constituted their means of subsistence. Mr. Grosvenor graphically describes the difficulties experienced in getting the Chukchis of Eastern Siberia to part with their cherished reindeer.

Naturalists will be greatly interested in a paper recently read by R. J. Pocock before the Zoological Society of London on the geographical distribution of the "trapdoor" and bird-eating spiders, in which it is pointed out that the zoological regions into which the world may be mapped out from the evidence of this group are practically identical with those indicated by mammals and birds. The importance of this can scarcely be over-estimated. We are glad to see that the author discards the terms "Palæarctic" and "Nearctic" in favour of "Holarctic," which embraces the northern portion of both hemispheres, and that he also recognizes a "Mediterranean" and a "Sonoran" region. His scheme differs, however, from some of those recently proposed by the absence of a "Malagasy" region; and now that the lemurs of Madagascar have been shown to be more closely allied to monkeys than was formerly supposed to be the case, perhaps the arguments for the separation of this island as a distinct region may be reconsidered.

The death of Monsieur P. du Chaillu recalls the great controversy which raged in the early sixties over the "gorilla question." If that great and energetic explorer had but been content with the honour of being the first to bring complete skins of the great West African ape to Europe, all would have been well. He was the discoverer of that most remarkable mammal the *Potamogale*, and also brought home the first skins of that lovely antelope the bongo, which was not, however, as he supposed, an altogether unknown species at the time.

It would be difficult to overrate the importance of Dr. C. W. Andrews' paper on the evolution of the Proboscidea, an abstract of which appears in a recent issue of the *Proceedings* of the Royal Society. Till the discoveries of Messrs. Andrews and Beadnell in the Eocene strata of the Fayum district of Egypt, the birthplace and origin of the Proboscidea were unknown. Both are now ascertained. Nor is this all, for Dr. Andrews is able to point out the mode of evolution of the trunk of the mastodons and elephants. In the ancestors of the group the lower jaw was short and stout with a short symphysis. As the animals increased in stature the lower jaw lengthened, this being mainly accomplished by the prolongation of the symphysis. In correlation with this a short trunk, formed by the upper lips and nose, was developed. Gradually the trunk increased in length, while the symphysis of the lower jaw shortened, till the evolution culminated in the long trunk and short lower jaw of the modern elephant. *Pari passu* with this were changes and modifications in the dentition, for the details of which our readers must refer to the original memoir.

A question as to the preoccupation and orthography of zoological names is incidentally raised by Dr. Trouessart in the April number of the *Annals and Magazine of Natural History* when describing the West Indian musk-rat. For this rodent the Doctor had previously proposed the name *Megalomys*, but as he finds this preoccupied by *Megamys*, the new title of *Moschomys* is suggested. In this course we believe the author to be fully justified. Many naturalists of the present day—especially Americans—will not, however, admit this, urging that if a name be ungrammatically formed or misspelt, it is entitled to stand as distinct from the orthodox name. The question urgently requires settlement by an influential body of naturalists so as to ensure uniformity of practice.

We are delighted to associate ourselves with the congratulations to our distinguished contributor, Miss Agnes M. Clerke, upon her election as Honorary Fellow of the Royal Astronomical Society, an honour in which she is associated with Lady Huggins, the wife of the President of the Royal Society.

British Ornithological Notes.

Conducted by Harry F. Witherby, F.Z.S., M.B.O.U.

Gulls as Grain Eaters.—On April 25th, on the small island called the Calf, that lies just to the south of the Isle of Man, I noticed a great number of small piles of what looked like chaff dotted here and there about the rocks. On inspection these turned out to consist of the shredded outside of grains of oats, the grain itself being represented, as a rule, only by small fragments. In some cases, however, the grains were there intact. In one instance there was a small pile of *débris*, half oats, half fish bones. There is no doubt that the Herring Gulls which were there in scores had been regaling heartily on the oats recently sown in the Isle of Man, and had ejected, on returning to their nesting places, what they found indigestible. Sometimes the "chaff" would be immersed in a fluid secretion, having just been brought up by the Gulls circling above. We have here a phenomenon similar to the ejection of pellets by Owls and Hawks, the only difference being that the indigestible shreds were floating in a fluid instead of being formed into a compact mass.—F. W. Headley, Haileybury.

Mortality among Cormorants, Shags, and Gulls during their First Winter.—I noticed both near Scilly and at the Isle of Man during last April what is certainly worthy of remark, viz., the very small number of young Cormorants and Shags (*i.e.*, last year's birds) compared with the mature birds. The young Cormorant is easily distinguishable by his dirty-white breast, and the young Shag by his brownish plumage.

very different from the glossy green of the adult bird. The small number of immature birds points to an enormous death rate among birds of these species in their first winter. Among Gulls the same phenomenon is, I believe, indisputable. At the breeding places in spring there are mature birds in huge flocks, far outnumbering the young birds which are to be seen, *e.g.*, in harbours.—F. W. Headley, Haileybury.

Hoopoe in Hampshire.—On April 25th last, while taking a walk in the New Forest, Mr. A. D. Sapsworth and myself had the pleasure of watching a Hoopoe. I have not seen the bird since, and fear that it has met with the same fate as most of the Hoopoes which visit our southern counties annually. On the same morning, I may mention, in a walk of some three hours we identified 49 species of birds.

The Arrival of Summer Migrants for 1903.—The following table of arrivals of summer visitors, compiled from various sources, may be of interest. The dates for first arrivals seem generally about the same as other years for the southern counties, but the inclement weather at the end of March and the beginning of April seems to have checked, probably in southern Europe, further migration, and to have stopped the birds from spreading northwards in England:—

Sand-Martin	March 23	Ireland, Wales, and West of England.
House-Martin	March 22	Wiltshire and Gloucestershire.
	March 27	Norfolk.
Swallow	March 21	Hampshire, Gloucestershire, and Ireland.
Chiffchaff	March 12	Berkshire.
	March 16	Oxford.
	March 24	Southern and western counties.
Wheatear	March 18	Hampshire.
	March 24	Southern and western counties.
Redstart	March 21	Hampshire.
	April 21	Wales.
Whinchat	March 20	Shropshire.
Blackcap	April 5	Devonshire.
Yellow Wagtail	March 23	Nottinghamshire.
	April 8	Gloucestershire.
Nightingale	March 31	Essex.
	April 7	Wiltshire.
	April 10	Hampshire.
	April 12	Suffolk.
Cuckoo	April 10	Kent.
	April 18	Essex.
	April 20	Hampshire.
Tree Pipit	April 17	Surrey and Staffordshire.
	April 20	Wales.
Grasshopper Warbler	April 21	Wales.
Lesser Whitethroat	April 22	Wales.
	April 29	Hampshire.
Swift	May 5	Hampshire.
Wryneck	April 6	Hampshire.
	April 12	Kent.
Willow Wren	April 19	Hampshire.
	April 26	Kent.

Early Nesting of Birds in 1903.—The following records of a few early nests may be of interest. The Nightingale's nest is extraordinary, but I have it on good authority.

Nightingale	April 18	3 eggs	Surrey (A. D. Sapsworth)
Song Thrush	March 6	Fledged young	Kent (J. F. Green)
	Feb. 26	Eggs	Kent (J. F. Green)
Robin	March 7	Eggs	Kent (J. F. Green)
Dartford Warbler	April 26	Feathered young in nest	Hampshire (H. F. W.)

Combative Green Woodpeckers.—One often sees in the early spring two male Green Woodpeckers engaged in a sort of mock combat over a female. In the *Field* for April 18th (p. 654), however, a deadly duel, which was witnessed by "J. E. S.," is described. He saw two birds fighting in the middle of a path. On his approaching, one of the birds (a Green Woodpecker) flew away, while the other bird "lay struggling on the path, severely injured, blood flowing copiously from its neck, and in a few moments it died." The dead bird was a male, and its neck was fearfully lacerated, while its tail and other feathers were pulled out.

All contributions to the column, either in the way of notes or photographs, should be forwarded to Harry F. Witherby, *at the Office of* Knowledge, 326, *High Holborn, London.*

Notices of Books.

"Spirals in Nature and Art." By T. A. Cook, with a Preface by Prof. E. Ray Lankester, F.R.S. Pp. xxi. and 200. (Murray.) Illustrated. 7s. 6d. net.—At Blois there is a staircase of peculiar form which there is reason to believe was constructed between 1515 and 1520 by a friend of François I. The name of the architect has hitherto been unknown, but Mr. Cook gives good reason for believing that the only man who could have designed the staircase was "Leonardo da Vinci, that great Italian artist, mathematician, scientist and engineer, who died in exile within a few miles of this very staircase a year or two after it had been begun." The spiral of the staircase appears to be the same as that seen in a section of the rare form of the shell *Voluta vespertilio*, in which the helix follows a left-handed instead of the ordinary right-handed curve. Leonardo would certainly have known of this natural spiral; moreover, he was left-handed, and ninety per cent. of the screws and spirals contained in his manuscripts are left-handed spirals. These and other facts go to establish Mr. Cook's thesis, and whatever may be the ultimate judgment upon the evidence brought forward, there is no doubt that he has produced a most interesting book which should direct attention to the work of one of the greatest intellects which the world has seen. It is perhaps worth remark that botanists regard the direction in which twining plants climb from above and not from below. The hop and honeysuckle thus climb in right-handed spirals, and the convolvulus in a left-handed fashion, but Mr. Cook, though familiar with these habits, refers to the two former plants as twining to the left, and the latter as exhibiting a right-handed direction. There are two ways of looking at most things, and this is very true in connection with directions of spirals.

"Papers on Mechanical and Physical Subjects." Vol. III. "The Sub-Mechanics of the Universe." By Prof. Osborne Reynolds, F.R.S. Pp. xvii. and 251. (Cambridge: University Press.)—An outline of Prof. Reynolds' new theory of the universe was given by him in his Rede Lecture, already noticed in these columns. The present volume contains the detailed mathematical analysis by which the ability of the theory to account for fundamental physical properties is demonstrated. The paper which makes up the volume was read before the Royal Society in February, 1902, and has been accepted by the scientific world as a contribution of great significance. For many years, the ether—a non-atomic continuous medium pervading the universe—has been called into being to explain action at a distance. Prof. Reynolds revolutionises this idea, and substitutes for the ether a granular medium having dimensions and properties which he shows are sufficient to satisfy the demands made upon physical theory. In his words this mechanical system "is neither more nor less than an arrangement, of indefinite extent, of uniform spherical grains generally in normal piling so close that the grains cannot change their neighbours, although continually in relative motion with each other; the grains being of changeless shape and size; thus constituting, to a first approximation, an elastic medium with six axes of elasticity symmetrically placed." Such an arrangement as this possesses very remarkable properties, and the dilatation which follows from strains caused by local inequalities in the density of the medium completely accounts for potential energy, the propagation of transverse waves of light, gravitation, and related facts. Prof. Reynolds has developed a theory which will make men of science associate his name with those of Newton and Maxwell. He has long been recognised as a versatile genius, and his latest contribution to science can justly be described as epoch-making.

"Comets and their Tails and the Gegenschein Light." By Frederick G. Shaw, F.G.S., &c. (Baillière, Tindall & Cox. 1903.) 2s. 6d.—This nicely printed little volume, illustrated with several views of Donati's comet and its orbital positions when near the sun, contains an attempt to explain comets' tails by the passage of the solar rays "through the gaseous atmosphere surrounding the nucleus of a comet, and thus rendered more vigorous and more capable of being reflected from the meteoric bodies, dust, etc., existing or moving through space or from the sun's atmosphere, if such a matter exists, in the vicinity of the comet." This practically constitutes a revival of the old view held by Tycho Brahé and others. The author does not appear to have made out a strong case. The peculiar forms displayed

by certain comets, the immense extent and curvature of some of their tails, and other facts appear to be decidedly opposed to Mr. Shaw's conclusions. Undoubtedly there are shoals of meteoric bodies circulating in planetary space, and it is probable that they are crowded in circumsolar regions, but it is very hard to believe that they could be rendered so strikingly visible over vast regions by the simple effects of refraction exercised by the heads of comets. It seems much more plausible to believe that the tail is born in a comet, and due to the emission of luminous material from the nucleus under solar action. On page 6 the author says, "the tail of a comet is invariably pointed—if one may use that expression—in the opposite direction to the sun," but this is not always accordant with observation. In certain cases comets have displayed two tails (those of 1823 and 1851 furnished examples), one of which was directed *towards* the sun. Mr. Shaw also alludes to the Gegenschein in his book, and attributes this appearance to the action of our atmosphere in "focussing the refracted rays of sunlight passing through it." It seems more probable, however, that the phenomenon is due to the reflected light of an assemblage of meteorites in the region opposite to the sun. We have noticed several errors in the book, thus, on page 15 we read, "the comet of 1774 is recorded to have had six tails." We suppose the comet of 1744 is referred to here. On page 27, Donati's comet is stated to have been "discovered by H. P. Tuttle on June 2, 1858."!

"The Burlington Magazine." Edited by Robert Dell. (The Savile Publishing Co.) 2s. 6d.—Whatever of reproach that has hitherto attached to England for the lack of a really artistic art magazine, can no longer remain an imputation upon our seriousness in art after the appearance of the *Burlington Magazine*, and for this reason alone we wish it success. But it has stronger claims to our support. Luxurious in margin, its text is enshrined in a large clear type, while it is actually printed on paper, paper that is, if we mistake not, quite innocent alike of the grass crop or the timber yard. As is fitting in such a work, it is in all respects a triumph of the typographic arts, while it excels in the finer and more difficult task of pictorial reproduction. Quite lavishly illustrated, but never cheaply, we have nothing but praise to bestow upon the many beautiful plates to be found in the work. The editor has written an admirable editorial article descriptive of the project, with the sentiment of which we entirely concur, and in all earnestness we offer our new contemporary a right royal welcome.

A selection of Mr. Lydekker's zoological and other articles from Knowledge is about to be re-issued by Messrs. Hutchinson under the title of "Mostly Mammals."

BOOKS RECEIVED.

The Stellar Heavens. By J. Ellard Gore, F.R.A.S. (Chatto & Windus.)

The Sciences. By Edward S. Holden. (Ginn.) 2s. 6d.

Plane and Spherical Trigonometry. By G. A. Wentworth. (Ginn & Co.) 4s.

Elementary Ophthalmic Optics. By Freeland Fergus, M.D., F.R.S.E. (Blackie.) 3s 6d. net.

Electrical Engineering Measuring Instruments. By G. D. Aspinall Parr, M INST.E.E., A.M.I.MECH.E. (Blackie.) Illustrated. 9s. net.

Practical Plane and Solid Geometry. By Joseph Harrison, M.I M.E. (Macmillan.) 2s. 6d.

Climatology. By Dr. Julius Hann. (Macmillan.) 12s. 6d. net.

Geometrical Optics. By Thomas H. Blakesley, M.A. (Whittaker.) 2s. 6d net.

Electrical Installations. By Rankin Kennedy, C.E. (Caxton Publishing Company.) 9s. net.

The Geography of Disease. By Frank G. Clemow, M.D. (Clay.) 15s.

Country Rambles. By W. Percival Westell. (Drane.) 10s. 6d.

Experimental and Theoretical Course of Geometry. By A. T. Warren, M.A. (Oxford and Clarendon Press.) 2s.

Class Book of Botany. By G. P. Mudge, A.R.C.SC., F.Z.S., and Arthur J. Maslen, F.L.S (Arnold.) 7s 6d.

Twenty-eighth Annual Report of the Savilian Professor of Astronomy to the Visitors of the University Observatory for 1902-3.

Substances Minérales. By A. L. Herrera. (Mexico: Officina Tip. de la Secretaria de Fomento.)

Dream of Realms Beyond Us. By Adair Welcker. (San Francisco: 331, Pine Street.) 40s.

Conditions of Progress in Electro-Chemistry. By Joseph W. Richards, M.A. (Bethlehem, Pa., Lehigh University.)

Journal of the Anthropological Institute. July to December. 10s. net.

Theory of Observations. By T. K. Thiele. (C. & E. Layton.) 12s. net.

Municipalisation of Secondary Education. By J. W. Richards, B.A. (Simpkin.) 6d. net.

Results of Meteorological and Magnetical Observations. (Stonyhurst College Observatory.)

Plan for the Endowment of Astronomical Research. By E. C. Pickering. (Cambridge, Mass.: Astronomical Observatory of Harvard College.)

Boletin del Cuerpo de Ingenieros de Minas del Perú. No. 2. (Lima: Imp. Torres Aguirre, Unión 150.)

Essex County Council Technical Instruction Committee Report and Handbook. (Chelmsford: John Dutton.)

St. Kilda and its Birds. By J. Wiglesworth, M.D., F.R C.P., M.B.O.U. (Liverpool Biological Society.) 1s. 6d.

Voigtländer & Sohn: Catalogue of Photographic Cameras, Lenses, and Accessories.

Another View of Industrialism. By William Mitchell Bowack. (Unwin.) 6s. net.

THE MOVEMENTS OF THE MACKEREL.

By L. N. Badenoch.

It is remarkable how little is really known of the life-histories of the marine food fishes. In the case of every other large food industry much time and thought has been expended from earliest times upon the laws governing the existence and increase of the objects composing the supplies. But fish, until lately, we were content merely to capture, quite regardless of their birth and habits. Endeavours to obtain information from fisherfolk and others who are continually in contact with fish have not proved altogether satisfactory, and it was seen that, before the industry could be brought into line with other industries, the matter must be taken in hand in a systematic and comprehensive manner. With this aim in view special investigations for the purpose of elucidating the various problems presented are now being made on both sides of the Atlantic. None are more interesting than the series of researches into the natural history of the mackerel, which have been recently undertaken at the request of H.M. Treasury. This important species, with its movements, is one of the most difficult of all the commercial fishes to study or to comprehend.

Seeing it is a pelagic fish, and has a freely floating egg, one might be led, with some reason, to suppose that it would thereby be enabled to spend its whole life without approaching the land. Fortunately for man, every season, during the warmer portion of the year, it leaves the open sea and migrates towards the shore, when its presence becomes apparent through its surface distribution, the only period when it can be fished for. It frequents the coastal waters in the northern temperate region of the Atlantic. On the Atlantic coast of Europe it extends from Bergen, in Norway, southward to the Straits of Gibraltar; and throughout the Mediterranean it also occurs, being taken in large quantities on the coast of Spain, the south coast of France, the coasts of Corsica, and in the Adriatic. Round the British coasts, the four principal regions for the fisheries are the North Sea to Norfolk, the Channel, and the south and west coasts of Ireland.

Along with, and contemporaneous with the migration, is the massing together of individuals into the well-known so-called "schools," or shoals. In this way, they swim crowded together during, at any rate, a great part of the year, and the shoals often contain an immense number of fish. Those pertaining to any particular shoal are usually of about the same size. Schools of large fish and schools of small fish may be present in the same neighbourhood at the same time, but schools of different sized fish do not

appear to intermingle. Similarity in size has also been observed to be usual in the shoals of grey mullet. It is, in fact, not well ascertained whether these mackerel schools are formed by chance association, or are due to the selective association of fish, having some characteristic in common. Such evidence as is to hand in the case of other fishes, in that of the grey mullet, for instance, points to the conclusion that the principle of selective association plays a considerable part in the formation of shoals, and that similarity of size is one of the points selected.

As to the manner in which mackerel keep together in shoals little is known. Grey mullet probably follow each other by sight The shoal seems to have no definite leader, but follows any individual that makes a dart in a particular direction. At night they lie on the surface of the water, their heads not all pointing one way, as they generally do by day, and they do not move as a shoal. It may be doubted whether other shoal fishes, as pilchards, habitually travel about as a shoal at night. The iridescent colouring of many fishes may assist them in keeping together in shoals.

The migrations of these shoaling mackerel have long been a subject of speculation among naturalists, and though much is known that was formerly obscure, it is a subject, in its various aspects, that presents peculiar difficulties to arriving at certain or definite information. It is not long since the value of statistics showing the quantities of the fish landed at various ports at different times of the year has been recognised, and from these, English and foreign, a number of tables have been constructed which give an insight into the distribution of the mackerel on the coasts in question during the different months of the year. Of this seasonal distribution as a whole it may be premised that, while the same general systematic movements can be observed, considerable variation takes place from year to year as to the exact date of the appearance of the shoals in a particular locality.

During the first two months of the year few mackerel are taken in any locality, the cold period being presumably the time when the fish are farthest from the coast. The few caught are chiefly found in the western part of the English Channel—at a distance of thirty to forty miles out at sea, south of Start Point and south of Plymouth—off the south-west coast of Ireland, off the west of France, and in small numbers in the Gulf of Marseille. Often during the greater part of March the conditions of February do not materially alter. Throughout that month, and in April, the mackerel in the English Channel continue a long way off-shore, becoming, however, more abundant. Towards the end of March, or early in April, generally speaking, large schools approach the south-west coasts of Ireland and the west coast of France, and the great spring mackerel fishery commences. At about the same time mackerel fishing begins in the Mediterranean In the eastern portion of the English Channel mackerel are not yet (April) taken in numbers, unless in exceptional years: at Dieppe some are taken in April.

The spring mackerel fishing reaches its height in May, and continues into June, becoming considerably less productive towards the end of that month. In the Mediterranean, on the west coast of France, on the south-west of Ireland, and in the western portion of the English Channel, during both May and June, the fish draw close inshore in great abundance, the fishing in all these districts attaining its maximum in May. In the eastern part of the English Channel, *e.g.*, St. Varley-sur-Somme, the fish are seldom plentiful before June; in the southern part of the North Sea a small fishery on the Danish coast begins in May; but at the English North Sea ports practically no mackerel are landed until June, and then they do not, in any measure, approach the numbers taken later in the year. Large shoals appear on the southern Norwegian coast, along the Swedish coast, and in the Kattegat, towards the end of May, and the principal fishery on these coasts is at its height in June.

At all the large fishing centres, as a general rule, a season of scarcity exists during July and August, between the great spring and autumn fisheries. Of this season on the south and west coasts of Ireland one of the inspectors says, there is a sharply-defined interval "between the two visitations of fish." It is true that at this time of the year mackerel in large numbers enter Plymouth Sound and inshore waters, where they are taken by whiffing lines and with the seine; but the mackerel appear to be scattered, and drift-net fishing is practically suspended. In Norway the summer fishing practically ceases about the middle of July. In the Mediterranean, at Cette, and at the majority of the ports, the great fishing is over in June, but to this Marseilles is an exception, the fish being generally plentiful until September.

September and October are the season of the great autumn fisheries. Immense schools visit the west coast of France and the south-west of Ireland, the quantities landed in some years equalling those of the spring fishery—a remark, perhaps, applying more strictly to Ireland. But as regards the west coast of England, practically an autumn fishery does not exist, and although on the south coast in most years the numbers landed increase in September as compared with August, they are by no means large, and show a decided falling off in October. After the beginning of September the mackerel leave Plymouth Sound, and are then caught in open water a few miles south of Eddystone Light, and south of Start Point. On the other hand, in the eastern part of the English Channel, and in the southern part of the North Sea—at the east ports of England and Gravelines—the most valuable fishery of the year is carried on at this time. During the last two months of the year, as during the first two months, mackerel fishing may be said to be closed on all the European coasts, though a few fish are still caught south of Start Point and the Eddystone, in the English Channel, and elsewhere.

The causes which bring about these periodic migrations are not by any means well understood. Study of the physical and biological conditions prevailing at different seasons of the year in the waters in which the shoals swim is being now undertaken, in order to throw light upon this important point. There can be little doubt that the temperature of the sea-water may be looked upon as one of the most important influences which determine—which may retard or accelerate the movements of the fish; though some have supposed the influence to be an indirect one, by determining the presence or absence of the organisms which constitute the mackerel's food in the several localities. When the fish first visit the coast in spring and early summer it is chiefly in order to spawn, and, plainly, the demands made by the needs of the young are met by proximity to the land, where the smaller organisms of the plankton abound, besides all the numerous larval forms of the creatures whose home is the coastal waters. During the latter part of summer, and in the autumn, however, when the mackerel are in the inshore waters, small fish of other species become abundant, which then furnish the mackerel with a generous food supply. On their first coming to the coast to spawn they are not readily taken with bait, because at this period they take less food, especially the females, which for a time indeed cease to feed. Thus, we may roughly term the first migration the "spawning migration": the approach to the coast in the summer and autumn is a "feeding migration."

Where do the mackerel go when they depart from the shore? Where are their winter quarters? One of the most generally accepted theories in the past, that they hibernate at the bottom of the sea in the neighbourhood of their summer haunts, was rightly condemned by some naturalists. Nor was an alternative suggestion, that they retreated to more southerly regions where they would find a favourable sea-temperature, and continued to live as during spring and autumn, near the surface, but in the open ocean, likely to be correct.

The conclusions that of late Mr. Garstang has come to profoundly modify the views which have hitherto prevailed concerning the extent of the migrations of this fish. He has clearly shown that the mackerel of the American and European coasts constitute two distinct varieties or races, possessed of differing characteristics, and also that there exist certain minor differences which appear to subdivide the mackerel frequenting the British coasts into two principal races, an Irish race, and those inhabiting the English Channel and North Sea.

This establishment of geographical or local races settles the dispute as to the length of the mackerel's migrations. The mackerel, Mr. Garstang points out, cannot cross the Atlantic; the pronounced difference exhibited between American and European fish proves that no mixture now takes place between the two races. Moreover, the difference revealed between the two principal British groups, the Irish and Channel fish, indicates that the mackerel of these regions do not travel far. Each race must have its own winter habitat, and this at no great distance from its summer haunts. In fact, the migrations, for the most part, resolve themselves into migrations from deeper to shallow layers of sea in the same localities. There is one exception, in the North Sea fish. The identity of the mackerel of the North Sea and English Channel—areas geographically contiguous—renders it certain that the theory is correct that the North Sea fish migrate from the English Channel in the spring, and return to it in the autumn. We have seen that while mackerel are in the western part of the Channel in March, few are taken in its eastern portion, or in the southern part of the North Sea before the end of May or in June. The important autumn fishery of these places, on the other hand, seems due to the movement of the fish on their journey back towards and through the English Channel. It may be that the early catches made off the south coast of England in December, January, and February, are the last of the autumn fish of the previous season moving down Channel on their emigration from the North Sea. That the first fish are caught to the eastward of Plymouth, subsequently travelling in a westward direction, to a few miles south-west of Eddystone Light, lends confirmation to this idea. This fact may also be considered in this connection, that in the Channel and North Sea the autumn fish appear to be slightly larger than the spring fish, and would seem to be the same fish at a more advanced stage of growth.

Doubtless the depth and extent to which the mackerel retire from the shore rests with the severity of the winter months. A series of expeditions for the purpose of investigating the seasonal changes of temperature and other conditions of the waters at the mouth of the English Channel have been lately accomplished, and the large quantity of material collected on the different voyages is receiving attention. If the expectations of the results of these observations be realised, a scientist will be able, having an adequately equipped vessel, to ascertain the most probable whereabouts of the schools of mackerel by his examination of the condition of the water at any given time. Such a result would revolutionize the state of the fishery industry, as from it would naturally follow the introduction of methods of fishing based on accurate scientific knowledge, in lieu of the unsatisfactory empirical ways still loved of fishermen in the present.

THE STRUGGLE FOR EXISTENCE IN SOCIOLOGY.

By J. Collier.

I.

It may seem strange that two men of gentle disposition and benevolent character, like Darwin and Wallace, should have originated the conception of a universal, perpetual, and relentless warfare as being waged among all genera, all species, all varieties, and all individuals. They can have had little notion of the way it would be taken up, or the extravagant lengths to which it would be carried. German and French anthropologists have raised a pæan to war. The old wars between peoples will give place to far more destructive wars between races. The blonde, long-headed race that has hitherto led the advance of mankind dreads impending defeat at the hands of the dark, broad-headed races that have long been hewers of wood and drawers of water. All previous battles will have been a sport to the great battle of Armageddon that the new century may witness. "Men will be killed by the million," Herr Gumplowicz prophesies, "for one or two degrees more or less in the cephalic index." The French anthropologists take up the running, and play the game of Germany. The progress of humanity, M. de Lapouge announces in strident accents, requires the extinction, by force or famine, of the backward and pacific races. In the twentieth century "the last sentimentalists will look on at copious exterminations of peoples." The civilizations of Europe, if Dr. Gustave le Bon is right, will end, as they began, with social convulsions.

Our own savants are less sanguinary, but have equally perverted the science it was their business to expound. Mr. Herbert Spencer relates that in the early fifties, when he and Huxley (sometimes accompanied by Buckle) walked together on Sunday mornings, the rising naturalist as strenuously opposed as he afterwards supported the evolution of species. Unlike Spencer, he "did not allow his imagination to outrun the facts." He never became a true Darwinian. He thoroughly grasped the doctrine of development, and aided in establishing it on two distinct lines. But he never took kindly to the characteristic Darwinian hypothesis—the theory of natural selection. Very late in life, he did realise that other Darwinian conception of the struggle for existence, and this time he allowed his imagination to outrun the facts. In his last years, while his pugnacity discovered everywhere in nature traces of conflict, his hypochondria universalised the signs of consequent suffering. Others have imagined a pitiless series of pitched battles, or an incessant warfare as prevailing in the ancient world.

Not only are all such views exaggerations, as Wallace calls them; they disclose a total misapprehension of the facts. The words used to name these facts are in good part answerable for the perversion. An eminent Russian sociologist, Mr. James Novikoff, has written a book,* saturated with Darwinian conceptions rightly understood and generously applied, and yet pervaded by the same prepossession of an omnipresent battle. W. Roux and E. Metchnikoff describe the battle for existence between the different parts of the organism. *La lutte, der Kampf;* battle, war, and even "the struggle for existence" seem

* "La Lutte entre Sociétés humaines." Par J. Novicow. (Paris; Alcan, 1896.)

to err by diffusing over the whole the accidental complexion of a part. War in all its phases is a pathological phenomenon like a surgical operation, a collision at sea, or an explosion in a chemical works. Ninety-nine hundredths of the normal processes of nature are of a wholly different character. The myriad dance of the atoms, molecular cohesion, attraction of gravity, chemical affinity, biological assimilation, and sociological union are different forms of the same fact. War consists in the comparatively rare collisions that mark the passage to these ends; the real struggle consists in the effort made by individuals or societies to overcome obstacles, to put forth all their powers, to shape new products, to realise themselves. Conflict with others is a mere incident of the real battle. War is not the type of social effort; it is the action of society in a state of disease.

Its Characters.

Count Gaston de Saporta has described the gradual transformation of vegetal species in prehistoric Provence. A single or a few individuals of a new species or variety appear in a given area. They may be immigrants, or the variation may have arisen on the spot in consequence of some outward change. The new form proves to be better adapted than the old to the changed environment. A conflict ensues. Step by step the immigrant or variant advances to the conquest of the entire area. Foot by foot the species in possession of it resists. The battle (what we call battle) may stretch through thousands of years. There are no visible signs of struggle. The "fairy fineness of ear" that Arthur Hallam ascribed to young Tennyson would hear no cries. None the less, a great racial battle has been fought and, in the long run, a great victory won. The invaders have, to all appearance, driven out the indigenous species, which survives only in inaccessible or less-favoured spots.

A Danish naturalist has ascertained the tactics of the battle. The birch is in possession of a tract. Its branches are open and let down the sunshine to its base, where the beech strikes root in the humus formed by the decomposition of birch-leaves. The beech grows up, and, being longer-lived, it survives and prevails over the birch, whose seeds can effect no lodgment under the dense shadow of the beech. Only in sterile or sandy tracts, by lakes or in marshy soil, can the birch hold its ground.

We perceive in what the battle, the victory, and the defeat consist. No single birch perishes till its time is come, but it leaves fewer and fewer offspring, and it fattens the soil for its supplanter. No tree has been driven out of its habitat; those that survive in inhospitable spots have been there from the first. It is battle by elimination, victory by supplanting, defeat by disappearance.

The vegetal elimination thus described is the type of all substitution of one species for another. Animal species become mobile, add to these tactics the destruction of a rival or hostile species. To the animal methods man superadds systematic warfare and wholesale massacre. The additions affect only the degree and the rate. In vegetal, animal, human, and sociological species the process is at bottom identical. War, as we know it, is a mere incident, or at best an intenser form of the conflict. It is not its type.

The Ethnical Struggle.

The old ethnology described in detail the long series of migrations in mass from "somewhere in Asia" that peopled Europe. Even so sober a historian as Amédée Thierry assigns dates to these great racial movements with a precision that rivals the pre-Noachian chronology of Archbishop Usher. The new ethnology is satisfied that no such collective displacements ever occurred. All the probabilities, such historical evidence as we possess, and the analogies of our own day combine to suggest that human races have generally migrated as plants and animals have migrated. But instead of reasoning hypothetically, on data drawn from language and anthropology, about the early European migrations, let us take a contemporary example. Every step and incident of the colonisation of New Zealand can be traced; the process, indeed, can still be observed, and for grasping it in its reality direct observation is, in some form, almost essential.

The early explorers, who touched at the islands but did not remain, resemble the adventurous seeds and individuals that vegetal and animal species send out as scouts. The first immigrant to New Zealand was the first runaway sailor from one of the exploring ships. If John Rutherford, whose instructive narrative was incorporated by Professor Craik in his "New Zealanders" of 1830, was the first (as he is the first known) of this variety, then is he the progenitor of all existing white New Zealanders. He was soon followed by other adventurers. Runaway whalers, escaped convicts from Australia, beach-combers, wandering Jews, and sometimes a stray educated man like F. E. Maning, arrived one after another on a scene where wild men found themselves in a congenial element. Altogether, it was estimated that there were 150 *pakehas* scattered over the North Island before its annexation. Missionaries accompanied or followed them. A British Resident was appointed. The ways having been opened and the ground prepared by these forerunners, it was felt that the time had come for systematic colonisation. Another adventurer, the great colonising genius Edward Gibbon Wakefield, organized a series of semi-commercial, semi-philanthropic associations which in course of years despatched some thousands of colonists. Smaller groups from time to time founded special agricultural settlements. The local Government brought out shiploads of artizans and domestic servants. But there has been comparatively little emigration in mass For the most part, it has taken place by individuals and families.

The resistance made by the natives to the early explorers was hostile, inspired by terror. When they got over their fright they received immigrants, the best and the worst, with impartial goodwill. Differences arose. War broke out; in the middle forties and the early sixties there was real war, waged by English generals, disciplined troops, and colonial auxiliaries. Though the two wars lasted for years and many battles were fought there was little destruction of life; perhaps a thousand Maoris at the most bit the dust. None the less, they have silently melted away "like snaw-wreaths in thaw," or like wax before a strong fire. From probably over 100,000 at the time of the British occupation of New Zealand, they sank in forty years to 40,000, and the decline steadily continues, in full peace, at the rate of one-eleventh in five years. As they have not been killed, neither have they been, on the whole, ill-used, two or three things have happened. They have mixed with the whites; 5000 half-castes are scattered through a population of 800,000, and in five years the number has increased by one-sixth. Next, ever fewer children are born. The large families of the old fighting days are no longer to be found. The natives themselves cannot account for the falling off; Darwin would ascribe it to the effect of the change of life on the most susceptible part of the system—the reproductive organs. The young die of consumption or other diseases induced by altered habits; drink has its hecatombs among the adults of both sexes. The older tribesmen die where they have always lived; the younger migrate. They cease to live by the side of the white man because they can no longer

make a living. In Australia, as in the United States, the mere presence of the white man drives into the interior the big or small game on which the black or the red man subsisted. There was little such game in New Zealand, but the brown man could no longer deliver himself to his old pursuits. The white wanted his land, and paid him to leave it. From day to day the steadfast encroachment could be observed. Wanting money for ordinary purposes or for some special purpose (as the costly celebration of a chief's funeral), the natives part with their land bit by bit, and when the land goes (as they are well aware) the Maori goes with it. When once daylight and air are let in on the dark and, sometimes, stifling New Zealand bush by a beginning of tree-falling, the destruction of an entire forest is only a question of time. The fate of the forest is the fate of the brown race Once it opens its ranks to admit even scattered members of a white race, its end may be retarded by bravery on its own part, or equity on the part of its conquerors, but its death is sure. In New Zealand, the last remnants will be found in the wild Uriwera country, whose fastnesses protect it against invasion.

The story is that of the birch and beech of Denmark. The methods of invasion, battle, and resistance are alike; alike, too, is the result. The earlier dark races have fattened the soil for the white invaders. They opened the bush, cut paths and cleared spaces, gave the grass time to grow, furnished servants, and often wives, to the immigrants, and sometimes fought on their side. Like Walt Whitman's redwood-trees, which rejoiced to be cut down for the use of man, they may congratulate themselves on being the forerunners of a greater race and thus aiding the advance of civilization. "The Government may take away my pension," said in 1884 a famous chief who had resolutely fought against the English twenty years before, "but it cannot take from me my loyalty to the Queen."

MICROSCOPY

Conducted by M. I. CROSS.

A POLARIZING VERTICAL ILLUMINATOR.

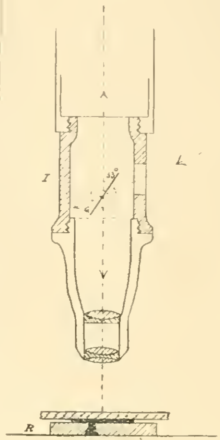
The interference tints produced by the polariscope in the examination of rocks and minerals enables the identification of constituents to be made by the petrologist. But in the thin sections which are commonly and necessarily prepared for the microscope, it frequently happens that the distinguishing colours are so faintly differentiated as to lead to confusion of identity, and although extraneous means are used for meeting the difficulties, even these do not yield distinctive results in all cases.

The new device of Professor Joly, described by him in the *Proceedings* of the Royal Dublin Society, is intended to aid observations to be made with increased accuracy.

The object under examination is laid upon a reflector of speculum metal (about 3 cm. diameter is sufficient), which is placed on the microscope stage, the thin cover of the specimen and not the slide being in contact with this reflector.

The illumination is effected with a vertical illuminator of the *disc* pattern, but with the aperture through which the light is admitted to the cover-glass disc reflector extended upwards to allow the illuminating beam to be directed upon the disc obliquely, so that the polarizing angle can be actually attained.

The accompanying diagram will make the matter clear. The illuminator is lettered "I," the cover glass for reflecting the light is shown at 33° with the vertical axis of the microscope, thus insuring that the light passing vertically through the object glass is at the polarizing angle (57° nearly) with the glass reflector.



Having adjusted the vertical illuminator disc so that the speculum reflector is illuminated, it will be observed that the reflected portion of the entering beam is plane polarized. Descending it passes through the slip carrying the rock section, then passing through the section it meets the speculum reflector "R" and is returned by it through the section and so back to the cover glass "C," the greater part of the beam passes upwards and reaches the eye; this is almost unmixed plane polarized light. A Nicol prism is, of course, used above the vertical illuminator.

It will at once be seen that the range of colour variation from one species to another will be greatly increased, the interference tints being the maxim proper to a plate of twice the actual thickness of the section in consequence of the passage of the polarized beam twice through the rock section.

Professor Joly further suggests that it will be found advantageous to perforate the reflector "R" with a small hole of conical shape, blackened inside so that when desired a small crystal can be examined simultaneously with the reflected ray and by light transmitted from the polarizer beneath the stage.

POND-LIFE COLLECTING FOR THE MICROSCOPE.

By CHARLES F. ROUSSELET, F.R.M.S.

THE fascinating study, under the microscope, of the living microscopic objects found in ponds, canals and lakes, collectively known as Pond-life, requires, first of all, that you should catch your game. The object of this note, therefore, is to discuss those methods of collecting which, with a good many years' experience, have proved to me the most practical, efficient and time-saving; it is intended for the young naturalist, or beginner, who desires to make the personal acquaintance of these minute atoms of life and thereby gain a better understanding of all living things.

Some few pieces of apparatus are indispensable, and these are the following:—

1. A Quekett's Collecting Stick with ring, net and bottle, and cutting hook.
2. A flat bottle.
3. A pocket magnifier.
4. A hand-bag with sundry wide-mouthed bottles.

THE COLLECTING STICK.—Can be obtained from most opticians: it is a hollow walking-stick with an inner rod to increase its length when required, and provided with a screw at the end for the attachment of either ring, net, dipping bottle or hook.

The ring is a stout brass hoop, about 6 in. in diameter. The net, which is sewn on to the ring, is made cone-shaped, about 6½ in. long, and at its apex is tied a small rimmed tube bottle of clear glass, about 3 in. long by 1 in. wide. The material of the net should be either fine muslin, known as "soft mull," with meshes fine enough to prevent the Infusoria and Rotifera going through and yet allowing the water to run out freely, or else a silk material known as "Swiss bolting silk," used by millers for sifting the various grades of flour, and obtainable from mill furnishers; No. 16 of this silk material has the required fineness.

The net is most important, and some care should be taken to have it properly made. Allowing a margin for the seam and for sewing round the ring, the shape and dimensions of the material for a 6 in. ring should be as represented in Fig. 1. This will give a net slightly larger than is required, but as the material is sure to shrink a little it will be of the right size after having been used once or twice.

The cutting-hook is a curved knife which can also be screwed on to the collecting stick, and is intended for cutting roots or water weeds which are otherwise out of reach.

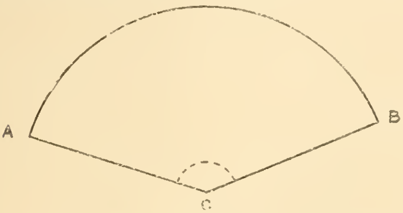


FIG. 1. $a\ c$ = 9 in.; angle at c = 140°.

THE FLAT BOTTLE.—Can now be obtained from the opticians, well made and cemented with fusible cement in the fire. When first invented by the late Mr. T. D. Hardy it was made by cutting a ⊔ shaped piece out of a thick flat piece of indiarubber or similar material, 4 to 5 in. long by 2 to 2½ in. wide, and ⅝ to ¾ in. thick; a square of thin plate glass of same size, cemented by means of Millers' caoutchouc cement on each side, completed the bottle. A thick piece of indiarubber is, however, so expensive that it is cheaper to buy the finished article. The flat bottle is used for searching over pondweeds with the pocket lens at the side of the pond, or examining the water which has been collected and condensed with the net. In round bottles it is very difficult to see minute animals clearly, whilst a thin flat bottle allows the whole contents to be readily scrutinized with a pocket lens of considerable power, and one can thus at once determine whether it is worth while to take home a sample from that particular pond for further examination under the microscope.

THE POCKET LENS best adapted for field work is Zeiss' improved aplanatic lens, magnifying 6 diameters, which has a very large flat field, long focus, and the most perfect definition all over the field.

The various groups of plants and animals commonly designated as Pond-life, which inhabit freshwater lakes, ponds and ditches, consist of Algæ, Desmids, Rhizopoda, Infusoria, Sponges, Hydræ, Rotifera, Polyzoa, Cladocera or Water-fleas, Copepods, Hydrachnida, Worms and Insect larvæ. All these can be divided for the purpose of collecting into two groups—the free-swimming, and those that are usually attached to water plants or submerged objects, and each of these groups must be captured in different ways.

All free-swimming or floating forms, which collectively are designated by the word "plankton," are best secured with the net. The net is passed through the water two or three or more times, and then held up; the water will run out in half a minute, and quite at the last the condensed animals will be seen entering the little bottle like a cloud, where they can be subjected to a preliminary examination. It is best, however, to empty the contents into the flat bottle, in which the examination with the pocket lens becomes very much easier, and most of the forms one is acquainted with can be recognized at a glance. In this way thousands of Algæ, Infusoria, Rotifera, Daphnia, &c., can be captured in a few minutes if the pond be a prolific one. Having thus ascertained that the dip contains some desirable forms, the water is poured into a larger wide-mouthed collecting bottle, of which three to six should be carried in the bag. These bottles should be numbered; for it is often advantageous to keep the water of different ponds separate, so as to be able to know at home from which pond a particular creature has come. Ponds vary exceedingly as regards their contents in Pond-life; a small pond may be very prolific, whilst another, possibly a larger piece of water only a few yards off, may contain hardly anything worth collecting. By trying all the different ponds, small and large, within reach of an afternoon's walk, one usually succeeds in obtaining a good gathering of free-swimming forms. The net quickly condenses a large volume of water, so that few species, even if present in small numbers only, will escape being captured. Several other methods of condensing pond water have been devised, but the collecting net with bottle attached is so simple and effective that we need not trouble about any other apparatus. It may be advisable to try the larger ponds in various places, and both near the surface and also in deep water, as some plankton forms may have collected in one particular corner of the pond and be absent elsewhere; this is often the case with *Volvox globator*. The use of a boat on larger lakes is very desirable when available. For Rotifers and other active free-swimmers it is not advisable to disturb the mud at the bottom of the pond, but certain species of Cladocera, Hydrachnida, and insect larvæ can only be found at or near the bottom.

(*To be continued.*)

PRACTICAL SCHEME.—Through the kindness of Mr. J. T. Neeve, of 4, Sydenham Road, Deal, I am able to offer for distribution four named varieties of Marine Algæ, mounted on paper, which can be kept either as herbarium specimens, or can be mounted as microscopic objects, for which latter they should be soaked in soft or rain water for twenty-four hours, which will cause the specimens to assume their natural state. Then mount in Dean's medium or glycerine jelly. If mounted in balsam in the dried state the cells are distorted and shortened. The instructions given for the mounting of Fungi, a few weeks ago, are also recommended by Mr. Neeve.

Applicants for these Marine Algæ are requested to enclose with the Coupon appearing in the advertisement pages of this number, a stamped, directed, square envelope, about 5 in. by 4 in. Particular attention is drawn to this point as it considerably reduces the amount of labour involved in this distribution.

Should any readers of this journal wish for further specimens, I should recommend them to apply direct to Mr. Neeve, at the address given above, who is both an authority and an enthusiast in this particular work.

NOTES AND QUERIES.

Lt. Damant.—The following would be the best manner for cutting sections of Marine Worms, to show the arrangement of parts:—Pin the worm, slightly on the stretch, on a strip of wood and harden in methylated spirit for ten days, changing the spirit every day for the first three days. Then cut the specimen up into pieces about ¼ in. long, place these in absolute alcohol and transfer to equal parts of absolute alcohol and ether and soak for about twelve hours. Place in a thin solution of celloidin for about twelve hours, transfer to a thicker solution of celloidin for twelve hours. Remove from celloidin on the point of a needle and expose to the action of the air until the celloidin drys, then push off with a needle into methylated spirit and soak for twelve hours to complete hardening of the celloidin. Place the infiltrated portion of worm between two pieces of carrot, fit it to the embedding arrangement of the Cathcart Microtome and make the sections. Stain in Grenacher's carmine, wash out excess of stain in methylated spirit acidulated with hydrochloric acid, one part acid and six of spirit. Then wash well in methylated spirit and place in absolute alcohol for two or three minutes, no longer, clear in oil of origanum and mount in Canada balsam. If preferable, the pieces of worm may be stained in bulk in carmine before they are infiltrated with celloidin. Permanganate of potash is used for decolourising sections when overstained with carmine, but the acidulated spirit answers quite as well and gives less trouble.

W. S. Rogers.—The most likely way to remove the siliceous matter is to boil the material in a weak solution of bi-carbonate of soda. If this is not successful the only alternative is to select the specimens from the *debris* by hand.

Pinacoid.—The only two makers of binocular dissecting stands of such low power as you require are Zeiss and Leitz, but it seems doubtful to me if either of them will exactly meet your conditions as to portability. The majority of such instruments are fitted with prisms at the eyepiece end, and have two tubes which are inclined at an angle one to the other, and necessitate the use of two objectives. Leitz's binocular preparation microscope, consisting of two Brücke lenses magnifying four diameters, only costing £3, can be taken to pieces for packing, and is of considerable value for preparation purposes. I think you would be better suited with an ordinary single lens dissecting microscope. Any London house would send you lists or particulars of Leitz or Zeiss microscopes.

W. S. Baxter.—I am sorry it is impossible to accede to your request: there are many simple explanations of Numerical Aperture given in various works on the microscope, the perusal of which will give you the desired information.

A. G. Watkins.—The only satisfactory way to test the magnification of a lens is to project the lines of a stage micrometer on a screen at, say, 30 in. distance from the back lens of the objective, measure the separation of lines so projected, and divide by three.

Seco.—The photographs that you send are exceedingly good, and you have every reason to be satisfied. The names of the specimens you wish identified are as follow:—(1) Species of Surirella; (2 & 4) Anchors and Plates of Synapta; (3) *Actinocyclus ralfsii*; (5 & 6) Wheel plates of *Chirodota violacea*; (7 & 8) *Heliopelta metii.* The centre specimen is a Radiate plate from *Myriotrochus rinkii.*

Communications and enquiries on Microscopical matters are cordially invited, and should be addressed to M. I. Cross, Knowledge *Office*, 326, *High Holborn, W.C.*

NOTES ON COMETS AND METEORS.

By W. F. Denning, F.R.A.S.

Present Comets.—There is no tolerably conspicuous comet now visible in the region north of the equator. Giacobini's (1903 a) is traversing the southern hemisphere, and at the beginning of June will be moving to N.W. in Octans, and in a position about six degrees from the S. pole of the heavens. Southern observers will probably have had a good view of this object during April. Early in that month it was about 80 times as bright as when first discovered, but its proximity to the sun at the period named must have prevented its being seen. On April 15th, however, it was 45° S. of the sun, and a rather striking and conveniently observable object from southern latitudes.

Giacobini's Comet (1902 b) passed very closely N. of α Geminorum (Castor) at the end of April, but was too faint for ordinary instruments. The increasing distance of this remote object, situated, as it will be, in the strong twilight of a June sky, will render it quite invisible.

Giacobini's Comet (1896 V.).—This faint comet, for which Prof. Hussey computed a period of $6\frac{1}{2}$ years, is due at perihelion on about June 22nd, and the conditions make it probable that it may be re-detected and followed during the ensuing summer and autumn. The predicted positions of the comet are given in an ephemeris by Ebelli of Kiel, for Berlin mean midnight:—

Date 1903.		R.A. H.	M.	S.	Dec. °	′	Distance from Earth in Millions of Miles.	Computed Brightness
June 2	...	23	50	47	+ 8	58	136	1·96
,, 6	...	0	2	50	+ 10	1	134	2·03
,, 10	...	0	14	52	+ 11	1	133	2·10
,, 14	...	0	26	53	+ 11	58	131	2·17
,, 18	...	0	38	51	+ 12	53	129	2·23
,, 22	...	0	50	47	+ 13	45	127	2·29
July 24	...	2	20	51	+ 18	17	116	2·60
Aug. 25	...	3	30	50	+ 18	19	106	2·70
Sep. 26	...	4	4	43	+ 14	12	97	2·66
Oct. 28	...	3	54	51	+ 8	6	96	2·21
Nov. 29	...	3	25	58	+ 4	6	114	1·26

Thus, at the opening of June, the object passes 4 degrees S. of γ Pegasi (mag. 3), enters Aries in July, and Taurus in August, while it will be placed immediately W. of the Hyades in September, thereafter moving very slowly to S.W. The unit of brightness in above ephemeris corresponds with that exhibited by the comet when last seen on 1897, January 4. As the date of perihelion is not accurately known, it will be advisable, when sweeping for the comet, to examine the region lying several degrees E. and W. of the positions given in the ephemeris.

The April Meteors.—At the period of the recent return of the Lyrids the weather was extremely cold and winterly, with severe frosts and hazy skies at night. Temperature offered a singular contrast to that experienced ten years ago, when summer heat prevailed, the maximum shade readings of a thermometer at Bristol being 1893, April 19, 75°; April 20, 77°; April 21, 81°; and April 22, 78°. The April meteors of 1903 were, perhaps, regarded with more than usual interest from the circumstance that just 100 years ago (viz., on the morning of 1803, April 20) a brilliant and abundant display of these objects was observed in America. There was, however, no visible repetition of that grand spectacle in the present year, for on the morning of April 20 the writer, at Bristol, watched a sky that seemed very still; meteors only came at long intervals, while the Lyrids were almost entirely wanting. At 1h. 40m. a.m., however, a sudden wave of light caused the observer to look towards N.W., when a very brilliant meteor was seen descending slowly from β Ursæ Majoris to β Camelopardi. In traversing a path of 39 degrees, it occupied $4\frac{1}{2}$ seconds, and left a thick train of yellow sparks in the immediate wake of its nucleus. Radiant probably at 218° − 31° (about 8° S.W. of 20 Libræ, mag. 3·3), from which point a well-pronounced shower of slow meteors was directed at the Lyrid epoch in 1900. This fireball may be said to have fittingly commemorated the centenary of the brilliant display witnessed in 1803. The April meteors generally appear to have presented no special activity or interesting features this year, but they were pretty well observed, and it is hoped to refer to some of the results next month.

Large Meteors.—April 11, 11h. 56m. G.M.T.—Fireball brighter than Jupiter observed at Lisburn, Ireland, by Mr. John McHarg. Flight directed from β Herculis, or possibly a little higher up, and ended near β Cygni.

April 19, 10h. 6m.—Fine meteor = ♀, observed by Prof. A. S. Herschel, at Slough. Path, 217° + 16° to 249° + 35°, and probable radiant at about 172° − 22°. Duration, $3\frac{1}{2}$ seconds. It left a short tail of red flakes.

April 21, 13h. 11m.—Large meteor, 3 × ♀, recorded by Prof. A. S. Herschel, at Slough, with a path very swiftly traversed from $131\frac{1}{2}°$ + 40° to $126\frac{1}{4}°$ + 34°. It gave a transient yellow flash, and was directed from the usual radiant of the April Lyrids.

April 22, 10h. 29m.—Meteor = ♀, seen by Mr. C. L. Brook, at Meltham, near Huddersfield. Path, 308° + 43° to 345° + 40°. Duration, $3\frac{1}{2}$ seconds. Colour, pale bluish-green. Observed also by Mr. G. W. Middleton, at Mexborough, who says the northern sky was lit up as by a flash of lightning. The fireball seemed to explode at about δ Cephei and to have been directed from near α Cephei. After falling 6° or 7° it burst out again with a beautiful greenish light, and expanded into a sort of nebulous halo.

April 22, 10h. 36m.—Meteor = ♃ recorded by Mr. T. H. Astbury, at Wallingford, shooting from 203° + 75° to 146° + 68° in $1\frac{3}{4}$ sec. It was a fine Lyrid, leaving a brilliant white streak. This meteor was also registered by Prof. A. S. Herschel, and adopting a radiant at 271° + 34° from the combined paths, the heights appear to have been from 70 to 56 miles over Northamptonshire.

THE FACE OF THE SKY FOR JUNE.

By W. Shackleton, F.R.A.S.

The Sun.—On the 1st the sun rises at 3.52 and sets at 8.3; on the 30th he rises at 3.48 and sets at 8.18.

Summer commences at 3 P.M. on the 22nd, when the sun enters Cancer; this is also the longest day, its duration being 16h. 33m.

Sunspots are now of frequent occurrence, and of late the solar disc has scarcely been devoid of spots.

The Moon:—

		Phases.	H. M.
June 2	☽	First Quarter	1 24 P.M.
,, 10	○	Full Moon	3 8 A.M.
,, 18	☾	Last Quarter	6 44 A.M.
,, 25	●	New Moon	6 11 A.M.

The moon is is apogee on the 13th, and in perigee on the 26th.

Occultations:—

Date.	Star Name.	Magnitude.	Disappearance. Mean Time.	Disappearance. Angle from N. Point.	Disappearance. Angle from Vertex.	Reappearance. Mean Time.	Reappearance. Angle from N. Point.	Reappearance. Angle from Vertex.	Moon's Age.
			h. m.	°	°	h. m.	°	°	d. h.
June 2	p^3 Leonis	6·2	9 44 P.M.	137	104	10 43 P.M.	267	231	6 23
,, 4	B A.C. 4294	6·1	8 14 P.M.	134	131	9 27 P.M.	274	258	8 22
,, 8	c^1 Libræ	6·0	1 23 A.M.	144	117	2 14 A.M.	233	201	12 3
,, 27	60 Cancri	5·7	8 42 P.M.	159	119	9 14 P.M.	234	196	2 15

The Planets.—Mercury is unobservable during the former part of the month, since he is in inferior conjunction with the sun on the 3rd. Towards the end of the month he is a morning star in Taurus, not far from Aldebaran, and is at greatest western elongation of 22° 5′

W. on the 28th, when he rises about $1\frac{1}{4}$ hours before the sun; the bright morning twilight will, however, interfere with easy observation.

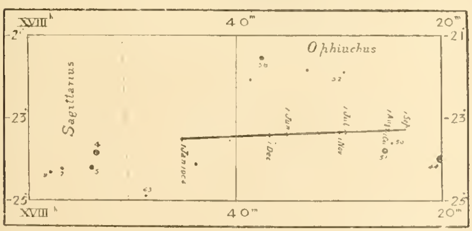
Venus continues to be the most conspicuous object in the evening sky looking rather north of west. The planet is increasing in brilliancy, and is so bright that it can easily be picked up in twilight, and observation may be continued until quite late, as she does not set until 11 P.M. The best time for observing is, however, soon after sunset, while it is still moderately light, as then the disc appears more sharply defined, and any outstanding colour of the telescope is less obtrusive. About the middle of the month the planet is on the meridian at 3.9 P.M., having an altitude of 59°; a little searching with a pair of field-glasses should enable one to detect this bright object in broad daylight. The diameter of the planet increases from 16″·6 at the beginning of the month to 21″·6 at the end. Near the middle of the month, 0·61 of the disc is illuminated, or the planet exhibits a phase similar to the half moon. On the 28th Venus is near the moon, and on the 23rd near the 6th magnitude star 83 Cancri.

Mars is still available for observation throughout the month until near midnight, setting on the 1st at 1.35 A.M., and on the 30th at 11.49 P.M. The planet is diminishing in brightness, also the diameter decreases from 10″·4 at the beginning of the month to 8″·4 at the end. The disc presents a gibbous appearance, 0·89 being illuminated. The latitude of the centre is +25°, so that the north polar cap is presented to us, and therefore the snow cap appears at the bottom in the ordinary inverting telescope. The planet is describing a direct or easterly path in Virgo in the direction of Spica; he is near the moon on the morning of the 4th.

Jupiter is in Aquarius, but does not rise before midnight until near the end of the month.

Saturn is in Capricornus, rising about 11.30 P.M. near the middle of the month, but on account of his great southerly declination he is not well placed for observation.

Uranus is on the confines of Ophiuchus and Sagittarius, and is in opposition on the 15th; the extreme southerly declination of the planet is such that he only attains the altitude of the mid-winter sun. The accompanying chart will enable the planet to be found, when it appears as a star of about the 6th magnitude, and can be seen occasionally with the naked eye, but readily with slight optical aid.



Path of Uranus in Ophiuchus.

Neptune is no longer available for observation, being in conjunction with the sun on the 26th.

THE STARS.—Position of the stars about 10 P.M.:—

ZENITH . Great Bear, Cor Caroli.
NORTH . Ursa Minor, Cepheus, Cassiopeia.
EAST . Cygnus, Lyra, Aquila, Sagittarius.
SOUTH . Hercules, Ophiuchus, Corona, Libra, Scorpio.
WEST . Leo, Cancer.—S.W.: Virgo and Bootis.—N.W.: Capella.

Chess Column.

By C. D. LOCOCK, B.A.

Communications for this column should be addressed to C. D. LOCOCK, Netherfield, Camberley, and be posted by the 10th of each month.

Solutions of May Problems.

No. 1.—(W. Geary).
1. P to Q4, and mates next move.

No. 2.—(T. Geary).
Key-move—1. K to Qsq.
1. . . . K to K5. 2. Q to Q3ch.

SOLUTIONS received from "Alpha," 2, 4; W. Nash, 2, 4; G. A. Forde (Major), 2, 4; "Looker-on," 2, 4; A. H. H. (Croydon), 2, 4; W. H. S. M., 2, 0; G. W. Middleton, 2, 4; J. W. Dixon, 2, 4; C. Johnston, 2, 4; H. S. Brandreth, 2, 4; H. F. Culmer, 2, 4; T. Dale, 2, 4; A. C. Challenger, 2, 4; W. J. Lawson, 2, 0; H. H. Bowdler, 0, 0; J. L. McLaren, 2, 4.

J. C. Candy.—Thanks for the problem.

J. W. Dixon.—Thanks for your appreciation.

A. C. Challenger and F. H. Worsley-Benison.—Solutions last month too late to acknowledge.

E. A. Servante.—Thanks for the problems. The three-mover cannot be used in a solution tourney as it has appeared before. The others will be printed ultimately if found up to the mark, but will have, I fear, to wait some time.

W. J. Lawson.—Is not 1. . . . K to K5 a sufficient answer to 1. Kt to Q4?

W. H. S. M.—You appear to have overlooked that after 1. Kt to Kt7 the King has an available square at QB4.

Hamilton White.—I can only suggest that you should send the end-game elsewhere. You are in error in supposing that the solution was "not obvious" to me. But I imagined the solution I found to be a "cook," and asked accordingly for the author's solution.

W. S. Branch.—Many thanks for your letters and cuttings. I maintain the silence which you request as to the other matter.

Mrs. W. J. Baird.—Many thanks; I give it in this number.

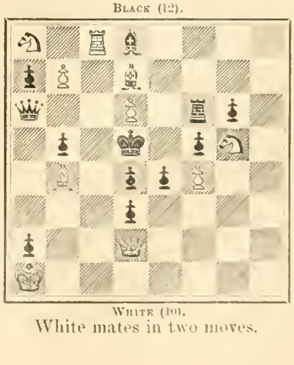
W. Nash.—I fancy that I have seen it before. Nevertheless it is very pretty and instructive, and may be new to most of our readers.

PROBLEMS.

By J. C. Candy.

No. 1.

BLACK (12).

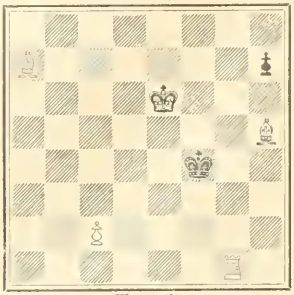


WHITE (10).

White mates in two moves.

No. 2.

Black (2)



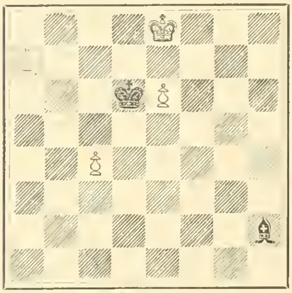
White (5)

White mates in three moves.

CONDITIONAL PROBLEM.

By Mrs. W. J. Baird.

Black (2).



White (4).

White retracts the move which he has just made, and plays another instead. Then Black plays so that White can mate on the move.

[This will, of course, not count in the Solution Tourney.]

Mr. W. Nash sends the following pretty end-game which is probably to be found in some standard work:—*White*, K at KKt8, R at K2, Pawns at KKt6 and 7; *Black*, K at Q2, R at KR8. White to play and win. The solution is 1. R to K6. If then 1. . . K×R, 2. K to B8, etc. Or if 1. . . R to KB8, 2. R to KB6, etc.

No objection having been lodged against the award in the Knowledge Problem Tourney, that award now becomes final, and the prizes will be sent to Messrs. Heathcote, W. Geary, and Lane forthwith.

CHESS INTELLIGENCE.

Mr. F. J. Marshall, while in London, won a short match against Mr. J. Mortimer by four games to love. At the time of writing, Mr. Marshall is leading in the "King's Gambit" Tourney at Vienna.

The "brilliancy" prizes in the Monte Carlo Tournament have been awarded to Herr Mieses and Mr. Pillsbury.

The game below, from the International Cable Match, is remarkable for the combination, beginning at the 25th move, by which Mr. Marshall turned the tables on his opponent. Mr. Atkins could nevertheless have drawn by 25. . . R×Kt; 26. R×R, B×R; 27. R×B, Q×R; 28. Q to K7, R to Bsq., when White would draw by perpetual check.

Queen's Gambit Declined.

White.	Black.
F. J. Marshall.	H. E. Atkins.
1. P to Q4	1. P to Q4
2. P to QB4	2. P to QB3
3. Kt to QB3	3. Kt to B3
4. P × P	4. P × P
5. B to B4	5. Kt to B3
6. P to K3	6. P to K3
7. B to Q3	7. B to K2
8. Kt to B3	8. Castles
9. Kt to K5	9. Kt × Kt
10. P × Kt	10. Kt to Q2
11. Q to B2	11. P to KKt3
12. P to KR4	12. Kt to B4
13. P to R5	13. Kt × Bch
14. Q × Kt	14. P to KKt4
15. P to Kt3	15. P to B4
16. P × P e.p.	16. B × P
17. R to Qsq	17. Q to Kt3
18. R to Q2	18. R to Q2
19. Castles	19. QR to Bsq
20. R to Bsq	20. B to Kt4
21. Q to B2	21. R to B5
22. Q to Kt3	22. Q to B3
23. R (Q2) to B2	23. R to Bsq
24. Q to R3	24. B to R3
25. P to Kt3	25. R to B4
26. Kt × P	26. R × R
27. R × R	27. Q × R
28. Kt × Bch	28. K to B2
29. Q to Q6	29. K × Kt
30. B to K5ch	30. K to B4
31. P to B3	Resigns.

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CONTENTS.

THE NOBODIES,—A SEA-FARING FAMILY.

By the Rev. T. R. R. STEBBING, M.A., F.R.S., F.L.S., F.Z.S.

CHAPTER VI.

IT is a disadvantage for any group to be without a popular name. To call the Pycnogonida "sea-spiders" is embarrassing, because it appears to class them with the Arachnida, from which good authorities consider them distinct. To call them "sea-insects" is still less satisfactory, because it sets wingless creatures flying in the face of facts. Some insects, it is true, are apterous, but none of them have more than six legs, whereas no representatives of this order have fewer than eight. Their superficial resemblance to the Phalangiidæ would suggest the term "sea-harvestmen," but it is cumbrous. The title of "Nobodies," alluding to their ascetic meagreness of frame, is too negative. To name them "sea-daddies," out of respect to the attenuated elongation of their limbs, might be thought undignified and over-familiar. A compromise may be found in the name "sea-spindles," agreeing with their Dano-Norwegian appellation "Söspindler." This has several recommendations. It recalls the services rendered to the tribe's elucidation by a long series of Scandinavian authors. It plainly notes the exclusively marine habitat of the group, and it is justified not only by the spindle-legged character of the species in general, but by the spindle-shaped proboscis in several, and the fusiform ovarial joints in the limbs of the females at maturity. In an interesting paper on the phylogeny of the group, J. E. W. Ihle ("Biol. Centralblatt," Vol. 18, p. 603, 1898) demands the acceptance of Pantopoda as its technical name, but Leach's Podosomata would have a preferential right, if there were the least necessity for relinquishing the time-honoured designation Pycnogonida.

Though the most critical discoveries connected with this subject were not first published in our language, several works of primary importance for an understanding of the whole matter have been given to the world in English. On the other hand, our native writers, as distinguished from those who have written in our native tongue, have not always been pre-eminent for clearness of description. Nevertheless, it is desirable to know what they have done, and where they have worked, both that we may have such credit as properly belongs to us, and that opportunities may be used in the future for clearing up what they have left obscure in regard to species inhabiting the home waters of Great Britain.

Pennant in his "British Zoology" (Vol. IV., p. 43, Pl. 19, Fig. 7; 1777) figures Ström's *Pycnogonum littorale*, showing that the species was then already known on our coasts, although its correct names did not penetrate our insular science till more than half a century later. In 1800 a paper entitled "Descriptions of some Marine Animals found on the Coast of Wales. By the late John Adams, Esq., F.L.S. Read February 6th, 1798" ("Trans. Linn. Soc., London," Vol. V., p. 7), begins with the following contribution to our subject:—

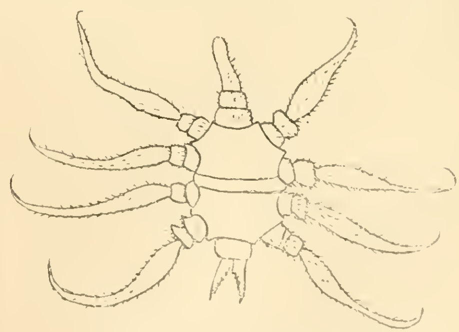
"PHALANGIUM.

"1. *grossipes*. P. corpore minuto cylindrico, humeris tuberculato, pedibus longissimis. *Linn. Syst. Nat. Ed.* 13. *p.* 1027. Milford Haven.

"*Obs.* To the minute and accurate description given in the *Systema Naturæ* I can have nothing to add, except that its colour is a dirty red.

"2. *hirsutum*. P. corpore subplano decemangulo. Tab. II. *Fig.* 1, 2. Milford Haven. Tenbigh.

"*Obs.* Body oval with ten angles, and marked with a transverse band near the centre; antennæ



Phalangium hirsutum, Adams. From Adams.

serrated on the interior side; feet eight, hairy; tail cylindrical, obtuse; colour palish brown; length $\frac{1}{3}$ inch."

It is not without interest to observe what could be regarded as minute and accurate description in natural history at the close of the eighteenth century. The second species evidently poses as new, but it is more like the already patriarchal *Pycnogonum littorale* than anything else, if we may regard the serrated antennæ as due to an

accidental slitting of the abdomen; but neither figure nor description shows for certain which is the head and which the tail of this problematical animal. Its names only once reappear when Leach, in the year 1816, in the fifth edition of the "Encyclopædia Britannica" by a slip of memory attributed them to Montagu in place of the species which that excellent observer really established. *Phalangium spinosum*, Montagu, found in South Devon ("Trans. Linn. Soc.," Vol. IX., 1808), still retains its earliest specific name. It was, however, very early confounded by Leach with the Greenland species *Pycnogonum spinipes*, O. Fabricius, and consequently transferred to Latreille's genus *Phoxichilus*. Hence arose a long-standing confusion, authors apparently supposing that the genus was based on the species from Devonshire, and not knowing that Latreille instituted it in 1804, before Montagu's species had been heard of.* In a later work (1810) it is curious to read the French professor's confession that he had even then only seen a single pycnogonid. This contrasts not only with modern testimony to the commonness of Sea-spindles but with a remark made by Leach as early as 1814, for at that date, when discussing Latreille's genus before the Linnean Society, he says of it, "I possess many indigenous species, but have not yet worked out their characters." Had he ever accomplished this working out, he would probably have found that he had been mistaken as to the generic affinities in at least some of his specimens.

A second species from the coast of Devon was described and figured by Montagu as *Phalangium aculeatum*. This was transferred by Leach to the genus *Nymphon*. It is misquoted by Costa in 1838 as *Phalangium oculatum*. Though it has otherwise dropped out of recent synonymy, it is probably identical with the earlier *Phoxichilidium femoratum* (J. Rathke), 1799. J. Rathke is not to be confused with the later and, at present, better-known H. Rathke. In designating his species as conspicuous for its femora or thighs, he unconsciously records his ignorance of the fact that this dilatation of the fourth or femoral limb-joint is a feminine attribute common to nearly all the tribe. It is safe to infer that he had a female specimen in view, while that which Montagu describes as having ovigerous legs, and which he figures with the thighs undilated, was clearly a male.

The next development of the subject by an English author is due to Leach, who, in 1814 ("Zoological Miscellany," Vol. I., p. 33), founded the genus *Ammothea* for an American species, leaving to subsequent observers the discovery of its English companions. In the same volume Leach described and figured his *Nymphum gracile*, adopting the distorted form of *Nymphon* apparently from Lamarck. The species, he says, "inhabits the British seas everywhere; but as it never attains the size of the *Phalangium*, misnamed by Linné *grossipes* (which is figured by Ström in his history of 'Sondmor,' 208, tab. 2, fig. 16), we are doubtful if it be the same species; but as the Linnean name is so ridiculously inapplicable, little fault can be found with the more appropriate name for which it has been exchanged" ("Encycl. Brit.," Fifth Edition, Art. Annulosa, p. 433). Still a little fault *can* be found. Leach, if he thought the English species identical with Ström's, should have adopted Ström's *marinum* as its name. Probably Linnæus in calling it *grossipes* thought only of the great length of the limbs, not of thickness, which that word more properly implies. But *gracile*, as it has turned out, is itself not a good choice, because it attributes to a single species the tenuity which is characteristic almost throughout the genus *Nymphon*. Nevertheless, *N. gracile* holds its ground, only not in place of *N. marinum* but by the side of it. *N. grossipes* (O. Fabricius) is distinct from both, an Arctic species likely to be rare if found at all in our waters.

In 1821, the American naturalist, Say, described a new genus and species as *Anaphia pallida* ("Journ. Acad. Philadelphia," Vol. 2, p. 59), which has this particular interest, that E. B. Wilson, in 1878, admits the possibility of having to cancel his own *Anoplodactylus lentus* in favour of his fellow-countryman's earlier names. The species itself is described by Verrill and Smith in their treatise on Vineyard Sound (1874), as a singular long-legged pycnogonid, clinging to and creeping over the hydroids and ascidians on shore and in shallow water, and most frequently deep purple in colour, though grey and brown specimens are also often met with. They borrow for it from yet another American author the name *Phoxichilidium maxillare*, Stimpson, 1853, but Stimpson's species is now accepted as itself a synonym of the still earlier *Ph. femoratum* (Rathke). Sabine's description of the great arctic *Colossendeis proboscidea*, in 1821, has been already mentioned. At the same time he discussed two arctic species of Nymphon, which, in a hesitating way, he identified respectively with the *grossipes* of O. Fabricius and the *hirtum* of J. C. Fabricius. Nymphon is probably a masculine form, but Nymphum is certainly a neuter one, so that Sabine's change of *Nymphon hirtum* into *Nymphum hirsutus* can scarcely be commended. None of his three species have been found in British waters, at least according to records that are above suspicion. The next English writer who contributed to enlarge knowledge, not only of the subject in general, but of its relation to our own fauna, was Dr. George Johnston. To him is due the genus *Pallene*, defined in 1837 for the species *P. brevirostris*, from the coast of Berwickshire (Miscellanea Zoologica, in Jardine's "Magazine of Zoology and Botany," Vol. I., p. 380). At the same time he established the genus *Orithyia*, a good genus, but with a pre-occupied name, for which Milne-Edwards, in 1840, substituted *Phoxichilidium*. The representative species had already been carefully described and figured by Johnston, in 1832, as *Nymphum coccineum* ("Zoological Journal," p. 489, 1828 on title page). Elsewhere he says, "It lives amongst sea-weed in Berwick Bay, and when at rest, with the legs drawn up, it so closely resembles some of the fine coloured confervæ, but more especially a detached portion of the Chóndria articulàta, as to be easily overlooked. It appears to me interesting, in so far as its transparency allows us to examine its circulating system with an accuracy which, perhaps, no dissection could enable us to amend" ("Loudon's Magazine of Natural History," Vol. 6, p. 42, 1833). This has proved to be the *Ph. femoratum*, already noted as occurring in the United States of America, and in South Devon. If Montagu gives his species "colour dusky black," while Johnston describes the body and legs "of an uniform fine transparent red colour," Sars corroborates both by saying that "the colour is generally a more or less vivid red, in particular of specimens from shallow water, and sometimes dark brownish, or a sepia tint."

The year 1837, in which the American writer Eights described his bright scarlet *Decolopoda australis** ("Boston Journ. Nat. Hist.," Vol. 1, p. 204), from the south, and Johnston inaugurated his new genera from the north, began a period of great activity in this subject. In 1838, the Italian O. G. Costa among his Neapolitan "Aracnidi," published the pycnogonid genus, *Phanodemus*, with three species which still await precise identification. To the

* *See* KNOWLEDGE, Vol. XXV, p. 187. On the same page, 14 lines from the foot the genus *Pallene* was by inadvertence attributed to Goodsir instead of Johnston.

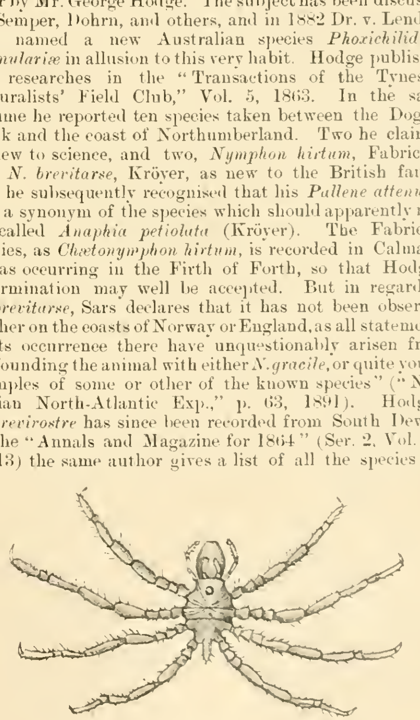
* It is most probably this species for which Rafinesque suggested the generic name *Decatelopus*, as he informs us in his Autobiography, p. 106, 1836.

same fauna A. Philippi, in 1843, contributed three more species in his genera *Endeis* and *Pariboea*. Unfortunately these also remain obscure. A year earlier Henry Goodsir described as *Pephredo hirsuta* a species from the German Ocean. The generic name is preoccupied. The genus is perhaps the same as Costa's uncertain *Phanodemus*. In the description of the figure the species is called by an

Phanodemus collaris, Costa. Clearly the dorsal, not, as Costa supposed, the ventral aspect.

alternative name *capillata*. On the obscurity of Goodsir's *Pasithoe vesiculosa* from the Firth of Forth comment has been already made. Hoek, in 1881, considers it "absolutely impossible to recognise," nor is it recorded either in the "Museum Normanianum" of 1886, or in Dr. Calman's still longer catalogue of specimens at University College, Dundee, 1901. Goodsir's *Phoxichilidium globosum* from Orkney, is supposed by Sars to be probably identical with the often mentioned *Ph. femoratum*. His *Nymphon giganteum*, taken in the sea at Embleton, off the coast of Northumberland, is identified with Ström's *N. marinum*. His *N. johnstonii*, from the German Ocean, his *N. pellucidum* and *N. minutum* from the Firth of Forth ("Edinburgh New Philos. Journ.," Vols. 32, 33), and his later *N. similis* ("Ann. Nat. Hist.," 1844), are foundlings which still utter feeble but unanswered cries for recognition. On the other hand, his *N. spinosum* is accepted by Sars as an undoubted member of Sars's own genus *Chætonymphon* (1888), and his *Pallene circularis* as belonging to Wilson's *Pseudopallene*, which as already shown, is a synonym of Latreille's Phoxichilus. At the same period attention was being paid to this subject by Milne-Edwards and Quatrefages in France, and by Erichson in Germany, but with more searching fulness by Kröyer in Denmark. The careful descriptions published by him in the Danish "Naturhistorisk Tidsskrift," were finely illustrated in the folio Zoological Atlas to "Gaimard's Voyage en Scandinavie." On the advances made by Kröyer, and the mistakes which even he could not wholly avoid, it is unnecessary here to expatiate, since subsequent authors have absorbed all that was meritorious in his work into more generally accessible languages. Our own Adam White described some foreign species in 1847, and two years later the great American naturalist, J. D. Dana, established a genus *Astridium* for an obscure little eastern specimen which he afterwards called *Pycnogonum orientale*. The arctic *Chætonymphon hirtipes* (Bell) was described in Belcher's "Last of the Arctic Voyages, 1855." In his useful little manual of "British Marine Zoology," of that same year, the late Philip Henry Gosse devotes a couple of pages and several figures to the Pycnogonida. It cannot, however, be said that this part of his work does much honour to the science of Great Britain. He is apparently quite ignorant of Goodsir's labours, but on his own account he supplies us with two new species, *Phoxichilidium olivaceum*, unrecognisably figured, and *Nymphon pictum*. Not a word of specific description is given. We are not told whence the species were obtained. We are even left to guess that they are intended for new ones.

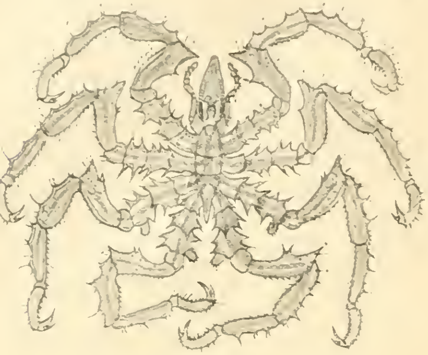
The parasitism of Phoxichilidian larvæ in hydroid zoophytes was, it is said, first discovered by Gegenbaur in 1854. It was then, as it seems, independently observed by Dr. Allman in 1859, and again, a couple of years later by Mr. George Hodge. The subject has been discussed by Semper, Dohrn, and others, and in 1882 Dr. v. Lendenfeld named a new Australian species *Phoxichilidium plumulariæ* in allusion to this very habit. Hodge published his researches in the "Transactions of the Tyneside Naturalists' Field Club," Vol. 5, 1863. In the same volume he reported ten species taken between the Dogger Bank and the coast of Northumberland. Two he claimed as new to science, and two, *Nymphon hirtum*, Fabricius, and *N. brevitarse*, Kröyer, as new to the British fauna. But he subsequently recognised that his *Pallene attenuata* was a synonym of the species which should apparently now be called *Anaphia petiolata* (Kröyer). The Fabrician species, as *Chætonymphon hirtum*, is recorded in Calman's list as occurring in the Firth of Forth, so that Hodge's determination may well be accepted. But in regard to *N. brevitarse*, Sars declares that it has not been observed "either on the coasts of Norway or England, as all statements of its occurrence there have unquestionably arisen from confounding the animal with either *N. gracile*, or quite young examples of some or other of the known species" ("Norwegian North-Atlantic Exp.," p. 63, 1891). Hodge's *N. brevirostre* has since been recorded from South Devon. In the "Annals and Magazine for 1864" (Ser. 2, Vol. 13, p. 113) the same author gives a list of all the species up



Pariboea spinipalpis, Philippi. From Philippi.

to that date noted as inhabiting the British seas. Of the thirty-two, seven are described as new to science, and three are reported as new to our fauna. Of the new species, two are placed in *Ammothoa*, by which Leach's *Ammothea* is intended, and three in a new genus, *Achelia*, which is usually deemed to be not really distinct from Leach's genus, but to represent its adult forms. Hodge's *Ammothoa brevipes*, a twenty-fifth of an inch in length, from the Durham coast, is thought to be probably the young of his *Achelia echinata*, now transferred to *Ammothea* His *A longipes* from Polperro is doubtfully

identified by Hoek with *Ammothea pycnogonoides*, Quatrefages, 1845. His *Achelia lævis* from Polperro is transferred to *Ammothea* by Sars. His *Achelia hispida*, from the same locality, remains unrecognized. His *Phoxichilidium*



Ammothea echinata (Hodge) $\frac{4}{5}$. From Sars.

virescens, also found in Cornwall, is assigned to *Anoplodactylus* (the synonym of *Anaphia*) by Sars, who further makes Hodge's *Pallene pygmæa*, from the Durham coast and Plymouth, a synonym of Kröyer's *Anaphia petiolata*. Of the three species of *Nymphon*, Kröyer's *mixtum* and *longitarse* were taken by Hodge himself on the Durham coast, and Ström's *mirinum* by Norman, who in his Shetland dredging report (Brit. Assoc. Rep. for 1868) refers to the capture as "a single specimen, the only known British example, dredged in 1861 in 80 fathoms, 40 miles east of Whalsey Skerries." In 1867 Hodge added a new species, *N. rubrum*, to our fauna from the coast of Durham.

In regard to the still vague genera and species which O. G. Costa introduced in his quaint and quaintly named Italian treatise, "Microdoride mediterranea," we must be content to name his *Platychelus sardonicus*, his *Alcinous vulgaris*, his *Alcinous megacephalus*, and to borrow sympathetically his quotation from Pliny, "In his tam parvis, atque tam nullis quæ ratio, quanta vis, quam inextricabilis sapientia!" which is as good as saying that in these little Sea-spindles, these insignificant Nobodies, there is such plan and power displayed as speak of a Wisdom past our finding out.

Little work has been done of late in Great Britain and Ireland on the Pycnogonida except by E. J. Miers ("Ann. Nat. Hist.," 1875; "Phil. Trans.," 1879; "Zool. of H.M.S. 'Alert,'" p. 323, 1884), and G. H. Carpenter, the latter of whom in 1892 ("Proc. R. Dublin Soc.," Vol. 7) founded the genus *Parapallene* to receive Hoek's *Pallene australiensis* and a new species, *P. haddonii*. On the other hand, in English have appeared several works of first-rate importance. Thus the "Challenger" report, by Dr. P. P. C. Hoek, in 1881, is a monograph teeming with instruction in our dialect, not in the author's native Dutch. The treatises by E. B. Wilson (1878, 1881), and T. H Morgan (1891) do credit to our language on the other side of the Atlantic. Dr. Meinert, of Copenhagen, in his excellently illustrated memoir ("Ingolf Exp.," 1899) addresses us in our own tongue, not in Danish. G. O. Sars, in 1891, sends forth from Christiania his pre-eminently valuable discussion of the group in parallel columns of English and Dano-Norwegian, supplementing both, after his manner, by that fine language of the pencil with which printed words cannot easily compete. In the works mentioned will be found long lists of literature, too long for reproduction here, or for critical analysis. Only exhausted limits of space indeed can excuse the omission of Lilljeborg, Hansen, Haswell, Ives, Ortmann, Adlerz, Caullery, Pocock, and others* from the present survey. Much has been said of mistakes and obscurities, yet scarcely a page can be studied without finding in it something useful and suggestive. If we pride ourselves on having valued works written by foreigners in our own vernacular, we have not a monopoly of such distinction. The Italian Philippi writes in German. The Russian Schimkewitsch writes in French and publishes at Rome ("Atti dei Lincei," Ser. 4, Vol. VI., 1890). Hoek's "Nouvelles Études sur les Pycnogonides," 1884, as the title implies, is written in French. This very valuable essay includes several pregnant observations on Dr. Dohrn's fine German monograph of the Mediterranean Pycnogonids. In the same way the Norwegian monograph by Sars not less usefully discusses the systematics of Hoek's "Challenger" report, and the whole series of works, throwing light each upon each, are gradually opening the way for well-ordered classification and luminous understanding. In his little "epoch-making" essays of 1876, 1877, the Italian Cavanna modestly explains that when he had made his discovery about the sexes in this tribe he could scarcely credit himself till he found that Dujardin, in 1849, and Semper, in 1874, had practically made the discovery, without having the courage to believe it. So it is in this small field, as Dryden says of a larger one, that "great contemporaries whet and cultivate each other, and mutual borrowing and commerce make the common riches of learning, as it does of civil government."

In the retrospect now concluded, an endeavour has been made to take note of all the genera, good, bad and indifferent, that have hitherto been set up. To have distinguished all the species would have taken far too long, and to have named them all without distinction would have been more tedious than useful. Some details of organization have been left unnoticed as too technical for the general reader. For naturalists who make the ocean their playground it should be satisfactory to know that the Sea-spindles are obtainable from its tide-marks downwards to three miles below the surface. In our islands they are not scarce. We can with some assurance boast of ten genera, and twice that number of species. In the milder Mediterranean climate their abundance is strongly attested. They flourish in the arctic regions. We have reason to be sanguine that they will yield good results to antarctic exploration. They are known from tropical waters. From all the coasts of Europe, from the seas of Asia and Australasia, of South Africa, and of America, both North and South, species have been obtained, so that the oceanic distribution of the tribe may be described as cosmopolitan. In natural history its past has surely not been uninteresting, and, one may venture to think, it has a future.

MODERN COSMOGONIES.

By AGNES M. CLERKE.

III.—THE NEBULAR HYPOTHESIS VARIED AND IMPROVED.

"RESTORATIONS" often go very far. Things may be improved beyond recognition, nay, out of existence. So it has happened to the Nebular Hypothesis. *Stat nominis umbra*. The name survives, but with connotations indefinitely diversified. The original theme is barely recalled

* Prof. A. E Verrill institutes the sub-genus *Ammothella*, in "Trans. Connecticut Acad.," Vol. 10, 1900.

by many of the variations played upon it. Entire license of treatment prevails. The strict and simple lines of evolution laid down by Laplace are obliterated or submerged. Some of the schemes proposed by modern cosmogonists are substantially reversions to Kant's "Natural History of the Heavens"; the long-discarded and despised Cartesian vortices reappear, with the *éclat* of virtual novelty, in others; nor are there wanting theories or speculations reminiscent even of Buffon's cometary impacts. Moreover, the misleading fashion has come into vogue of bracketing Kant with Laplace as co-inventor of the majestic and orderly plan of growth commonly designated the "Nebular Hypothesis." This has been, and is, the source of much hurtful confusion. Save the one fundamental idea—and that by no means their exclusive property—of ascribing unity of origin to the planetary system, Kant's and Laplace's evolutionary methods had little in common. Their postulates were very far from being identical; they employed radically different kinds of "world-stuff": and the "world-stuff" was subjected, in each case, to totally dissimilar processes. Yet it is often tacitly assumed that to defend or refurbish one scheme is to rehabilitate the other. Under cover of the intellectual vagueness thus fostered, a backward drift of thought is indeed discernible towards the standpoint of the Königsberg philosopher. It is recommended, not so much by the favourable verdict of recent science as by the wide freedom of the prospect which it affords. The imperative guidance of Laplace, reassuring at first, led to subsequent revolts. But Kant is highly accommodating; one can deviate widely from, without finally quitting the track of his conceptions; they are capacious and indefinite enough to comport with much novelty both of imagination and experience, and hence lend themselves with facility to the changing requirements of progress.

A noteworthy attempt was made, in 1873, by the late Édouard Roche, of Montpellier, to reconstruct, without subverting, Laplace's Hypothesis. This remarkable man lived and died a provincial; only a few scattered students have made acquaintance, at first hand, with his works; his fame, always dim, now already begins to seem remote. Yet a score of years ago he was still lecturing at the Lycée of his native town. The waters of oblivion have grown, perhaps, more turbid than of yore. Anyhow, Roche of Montpellier is only vaguely remembered, and that by a specially educated section of the public, as having fixed a limit within which a satellite cannot revolve intact.* Nearer to the ruling planet than 2·44 of its mean radii, it could not—apart from improbable conditions of density—maintain a substantive globular status under the disruptive strain of tidal forces. In point of fact, all the moons so far discovered in the solar system circulate outside "Roche's Limit"; and Saturn's rings, which lie within it, owe to that circumstance, it may plausibly be asserted, their pulverulent condition. Professor Darwin, accordingly, considers knowledge of that condition to date from 1848, the year in which Roche published the law involving it as a corollary.†

Roche was the precursor of Poincaré and Darwin in those momentous investigations of the figures of equilibrium of rotating fluid bodies which have opened up new paths and disclosed untried possibilities in evolutionary astronomy. His researches, moreover, into the origin of the solar system ‡ constituted a reinforcement of primary account to the strength of Laplace's position. He was perhaps its most effective defender, repairing breaches, and throwing up skilfully constructed outworks. Adopting the same premisses, he drew virtually the same conclusions as Laplace, ingeniously modifying them, however, so as to evade certain objections, and temporarily to silence the less obstinate cavillers. His results were, indeed, almost as difficult to disprove as they had been to obtain. They were arrived at laboriously, legitimately, by long-drawn analytical operations; and the reasonings survive in full credit, even although the initial conditions they started from now wear an aspect of unreality. Thus, the invention of *trainées elliptiques* not only usefully met an argumentative emergency, but still remains as a supplementary adjunct to cosmic processes. Undeniably, polar annulation may have played a part in planetary formation; the possibility cannot be gainsaid The "elliptic trains" investigated at Montpellier were huge nebulous strata detached from the polar regions of the primitive spheroid, which, bringing with them the low rotational velocity proper to that situation, tended, some to constitute interior equatorial rings, others to become agglomerated with the central mass. But their incorporation should have had as its consequence—since the "law of areas" is inviolable—a quickening of angular rotation throughout the nebula. The "law of areas," it may be explained, is merely a short title for the "law of conservation of moment of momentum," which prescribes—as we know—that the sum-total of the areas described in a given time on a given plane by the members, or constituent particles of a rotating system, multiplied by their several masses, remains constant under all conceivable circumstances of re-arrangement or mutual disturbance. Hence, approach towards the centre, because it narrows the circle, must quicken the speed of rotation. A short line having to sweep over the same space as one of greater length, its moving end must proportionately hurry its pace. An engulfment, accordingly, by the embryo sun of one of Roche's "elliptic trains" would have occasioned an immediate shortening of the period of revolution of both nucleus and atmosphere, an accession of centrifugal force producing sudden instability, and, as a consequence, the separation of an equatorial ring. By this subtly-devised expedient, Roche sought to explain away the difficulty connected with the wide intervals between the planets. For they originated, he conceived, not in the regular course of condensation, but through complications arising abruptly, and exceptionally. The "limiting surface"—as he called it—of the nebula might also be described as the atmospheric limit. It corresponds to the widest possible extension of a true atmosphere. Its boundaries are at the distance just outside of which a satellite could freely circulate in the axial period of its primary. Now the limiting surface, if contraction had proceeded equably, should have retreated continuously, its withdrawal being attended by the shedding of slender rivulets of superfluous matter. But by the introduction of "elliptic trains," stability, artificially maintained (so to speak) throughout long spells of time, was overthrown only by catastrophic downrushes from the shoulders of the nebulous spheroid, when, with the prompt abridgment of the axial period, the limiting surface as promptly shrank inwards, and there was left, outstanding and self-subsistent, the tenuous ring destined to coalesce into a planet. A singular and unexplained felicity of Roche's analysis consisted in the symmetry of time-relations established by it. The successive births of his planets appeared to follow each other at equal intervals. Bode's law of distances (extended by him to satellite-systems) was thus translated in terms of the Nebular Hypothesis.*

* "Mémoires de l'Acad. Montpellier," t. I.

† "The Tides," p. 327.

‡ "Mémoires de l'Acad. Montpellier," t. VIII.

* Wolf, *Bull. Astr.*, t. I., p. 596.

Kirkwood, in 1864,* had recourse to solar tidal friction for the purpose of changing planetary axial movement from an anomalous into the conventional direction. And he was followed, doubtless independently, by Roche, and by Roche's interpreter, M. C. Wolf, of Paris. Objections to any particular mode of planetary formation, on the ground that its outcome must have been retrograde rotation, lost their validity, they remarked, through the consideration that solar tidal friction would have availed to redress the incongruity. For its retarding action would have ceased only when synchronism with the revolutionary period was attained; that is, when the planet wheeled in its orbit, as Mercury seems to do, turning always the same face inward; and then already direct rotation would have set in, and, becoming accelerated by contraction, should permanently retain the direction impressed upon it by the friction of sun-raised tides. A certain air of plausibility is given to this view by the fact that the only two retrograde planetary systems are situated entirely beyond the possible range of any such manner of influence, and may accordingly be supposed to have preserved unaltered their primitive fashion of gyration.

The late M. Faye was less loyal to tradition than the *savant* of Montpellier. The appearance, in 1884, of his work "Sur l'Origine du Monde" gave the signal for renewed activity, and a larger license in cosmological speculation. Conservative opinions on the subject are now rarely held; the old groove has been, by most, definitively quitted; enquiry becomes continually more individual, and less constrained by prescription. Faye's reform, however, was not avowedly of a revolutionary character. He did not make a clean sweep of the work of his great predecessor, by way of preliminary to setting forth his own more perfect plan. Yet his emendations of it went very deep. Laplace's nebula was of a gaseous consistence, and it stood in a genuine atmospheric relation to the central condensation. That is to say, its strata gravitated one upon the other; they were subject to hydrostatic pressure. Faye ruled things otherwise. The nebulous matrix which he postulated was a vast congeries of independently moving particles, forming a system governed by a single period, in which both gravity and velocity increased in the direct ratio of the distance from the centre. Now globes formed by the method of annulation (admitting its practicability) out of materials thus conditioned should have possessed, *ab initio*, a direct rotation; their axial spinning would have been in the same sense as their orbital circulation. And this it was which recommended to Faye the adoption of a meteoric structure for the inchoate solar system. But the simple law of force regulating it at first would, by degrees, have become essentially modified. That of inverse squares, familiarised to ourselves by long habits of thought, would have begun to supersede it so soon as a sun, properly so-called, could be said to exist. The retrograde planets Uranus and Neptune must, however, by Faye's supposition, have taken shape under the modern regimen; they were then formed subsequently to the earth and all the rest of her sister orbs. This unexpected inversion of the recognised order of planetary age involved the further consequence that the ante-natal offspring of the sun—thus paradoxically to designate them—must have drawn closer to him as his attractive power developed, Uranus and Neptune alone among the entire cortège preserving the original span of their orbits.

Faye's scheme, if it did not meet all the arduous requirements of the problem it confronted, served at any rate to illustrate very forcibly the devious variety of tracks by which nebular evolution might advance towards its goal. The particular one chosen was certainly not clear of impediments. In his pre-occupation with the removal from Laplace's Hypothesis of the flaw relating to planetary rotation, M. Faye had discarded its cardinal merit of explaining secessions of material by the growth of centrifugal force; for no sufficient reason could be alleged why the remodelled nebula should have separated into rings.* The process implies definite and special conditions; it testifies to a symmetrically acting cause. Laplace brought such a cause into play. Faye abolished it, and his annuli, accordingly, wear a fictitious aspect. It is indeed true that an annular structure is commonly visible in nebulæ; but it is begging a most arduous question to assume that nebular spires have anything in common with planet-forming rings.

These would probably never have been heard of save for the Saturnian example. A pattern is easily copied; an idea palpably feasible is tempting to adopt; a demonstration on the *solvitur ambulando* principle cannot but prove convincing. But how, if the rings cannot be made to coalesce into globes? And the difficulty of the transformation becomes more apparent the more clearly its details are sought to be realised. Reversed in direction, it might better find a place in the order of nature. "Analysis seems to indicate," Kirkwood wrote in 1884,† "that planets and comets have not been formed from rings, but rings from planets and comets."

Faye's theory was disfigured by a still more glaring incongruity. Nothing in the planetary economy seems more evident than that the zone of asteroids marks a division between two strongly dissimilar states of the solar nebula. It is a visible halting-place. One series of events came to an end, and there was an interlude before the next began. During that interlude, during the partial suspension of activity which ensued upon the production of the Ajax among the planets, the crowd of planetoids were launched to fill the blank space. Here, if anywhere, nature changed her hand, and tried a fresh method. Faye's shifting of the scene of change to trans-Saturnian regions is then, as M. Wolf justly perceived, non-natural, and undermines the credit of a plan to which the device is essential.

On the other hand, it had the merit of being elastic enough to include the great cometary family. Kant had also, although in an unsatisfactory manner, made room for them; but Laplace had no choice save to regard them as casual intruders from space, the admission of which as natives of his well-ordered domain would have led to the subversion of all its harmonious regulations. Modern enquiries, however, prove comets decisively to be no such stray visitors as Laplace supposed, but to be of the same lineage—however remotely traceable—with the planets, and to own the same allegiance. Drifting with the sun, they form part of its escort on its long, irrevocable voyage, and cannot, save by accidents of perturbation, be driven finally to part from its company. The problems of planetary and cometary origin are then inseparable; the two classes of body are fellow-citizens of one kingdom. Comets become only by compulsion cosmopolitan wanderers from star to star.

There was yet another motive, and semblance of justification, for Faye's reform of the Nebular Hypothesis. The discovery of the conservation of energy supplemented, as we have seen, very happily the mechanics of a condensing nebula by satisfactorily solving the enigma of solar radiation. Helmholtz was thus able, in 1871, to sketch

* *American Jour. of Science*, Vol. XXXVIII., p. 3.

* G. H. Darwin, *Nature*, Vol. XXXI., p. 506.

† *Proc. Amer. Phil. Society*, Vol. XXII., p. 109.

cosmic development as, in its essence, a thermodynamic process on the grandest scale. Yet the alliance entered into, fruitful and fortifying though it was, had an attendant embarrassment. Time had now to be reckoned with. In the cosmogonies of Kant, Herschel and Laplace the allowance of aeons was unstinted. Because the rate of change was indeterminate, they might be permitted to elapse *ad libitum.* But it was otherwise when the driving-power came to be defined. "Conservation of force" implies the measurableness of force. Equivalence cannot be ascertained where no limits are determinable. Knowledge, accordingly, regarding the source of the sun's heat brought with it the certainty that the source was by no means inexhaustible. The stock of energy rendered available by shrinkage from a primitively diffuse, to its present compact state, was enormous, but not boundless. The task then became incumbent upon cosmogonists of proving its sufficiency, or of eking out its shortcomings. The problem is both retrospective and prospective. We look back towards the birth of the sun, we look forward to its demise; and each event has, if possible, to be located on our time-scale. Helmholtz assigned terms of twenty-two millions of years in the past, and seventeen millions in the future, for the shining of our luminary with its actual intensity. Geologists and biologists, however, claimed a much more extended leisure for the succession of phenomena on this globe; and efforts on the part of physicists to meet their demands barely availed to tone down without removing the discrepancy. M. Faye then came to the rescue. His suggestion that the earth took separate form while the sun was still nebulous, was designed to conciliate the demands of those who needed all but eternity for the slow accumulation into specific differences of infinitesimal variations. In this way, a start was gained upon the sun; the preparations for vitality on our planet were going forward long before the lavish radiative expenditure designed to nurture its development had begun. The earth, in fact, was shaping itself for its destiny in advance of the epoch when time began to count for the sun.

This supposed relation of precedence cannot, indeed, be insisted upon; it was imagined to save a difficult situation, and intimates a design more or less academic. The expedient, however, was significant as regards the effect of the introduction into modern thought of the principle of the conservation of energy. It gave definiteness and a kind of solidity to speculation by widening the basis upon which it was made to rest. At the same time it necessitated adjustments between the exigencies of the various sciences, and brought into prominent view apparent incompatibilities only to be removed by prolonged investigations of wide scope and intricate bearings. Modern cosmogony, in short, while disposing of enlarged means has to meet multiplied exigencies.

Sir Robert Ball, nevertheless, regards the origin of the solar system chiefly under its mechanical aspect. Like Helmholtz and Faye, he chooses pulverulent materials to work with; his nebula is a "white nebula." Looking still further back, however, he discerns as its parent an irregular "green" nebula, the jostling movements in which becoming regularised by the elimination of colliding particles, it became flattened down into the "plane of maximum areas"—the fundamental plane conformed to more and more closely as the energy of a system inevitably wastes. He dispenses with the troublesome process of annulation, and starts his planets virtually by Kant's method of accidental nuclear condensation.* A spiral structure, moreover, would be imparted to the entire nebula by the gradual propagation outward of the central acceleration due to contraction.

But would it have contracted? It had, by supposition, reached the stage of approximate unanimity in movement. The great bulk of its constituent bodies circulated in the same direction, in nearly the same plane, and presumably in orbits not deviating much from circularity. Their aggregate condition might then be regarded as permanent and stable The central mass would, accordingly, no longer be fed by the engulfment of particles brought to rest by their mutual impacts; motion being unimpeded, heat could not be evolved; and the imagined transformation of a disc-like meteoric formation into a sun and planets would fail to come to pass.

What then, we may ask ourselves, is the upshot of these various efforts at reconstruction? They establish, certainly, the unassailable unity of the solar world; and the solar world must be understood to embrace comets and cometary meteors. The arguments favouring this unity have gained enormously in cogency through modern discoveries. For those depending upon structural coincidences and harmonies of movement have been reinforced by others of a totally different nature, furnished by the doctrine of the conservation of energy and the teachings of spectrum analysis. The sun is hot because it was anciently expanded; the energy of position formerly belonging to its particles incontestably provided its present thermal energy; and this amounts to saying that a sphere indefinitely great was once filled by our inchoate system. The conclusion that it arose from an undivided whole through the gradual differentiation of its parts is further ratified by the identity of solar and terrestrial chemistry. Thus, the earth once made an integral part of the substance of the sun; and what is true of the earth is no less true of its sister planets.

Regarding the *modus operandi*, however, of cosmic change, there is no consensus of opinion. Faye alone has striven to elaborate a process enduring the modern tests of feasibility, and his theory has been well-nigh torn to pieces by adverse criticism. That there was, in the beginning, a solar nebula, all are agreed; but whether it was gaseous or pulverulent, whether it shone with interrupted or continuous light, how it became ordered and organised, how it collected into spheres, leaving wide interspaces clear, the wisest are perplexed to decide.

Mr. Moulton concludes from his careful examination of the subject, that "the solar nebula was heterogeneous to a degree not heretofore considered as being probable, and that it may have been in a state" resembling that exhibited in recent photographs of spiral nebulæ.* But, even if all the facts do not chime in with this tempting analogy, there can be little reason to dissent from his intimated opinion that "the Laplacian hypothesis is only partially true, and that we do not yet know the precise mode of the development of the solar system."

WHAT IS THE MILKY WAY?

By C. Easton, d.sc.

The Milky Way, a "bow in the heavens" in monochrome, and permanent, is unfolded on the celestial vault as the most strange and most amazing of optical errors. Supposing that our retina—an admirable instrument, the most sensitive organ with which God has gifted our body, but yet far from being perfect—supposing that it were improved to such a degree that the extremities of its nervous ramifications presented surfaces that were ten or a hundred times

* "The Earth's Beginnings," p. 247.

* *Astroph. Journal*, Vol. XI., p. 139.

on a smaller scale to the rays of light; then the images of many small and very close stars would each find their own path of communication with the brain, there would no longer be a "confusion in the despatch." It is true that the accumulation of luminous impressions which takes place now would not be produced, but, instead, all the small stars, down to a certain magnitude too feeble for our perception—say, to the 9th or 10th magnitude—would be seen individually in the sky. In such a case we should see on very clear nights a great crowding of stars along a somewhat irregular curve—300,000 stars in the visible hemisphere; it would be like the great atlas of Argelander, the celebrated "Bonn Durchmusterung," spread out on the celestial vault. But we should see nothing of the "Milky Way"—except on a somewhat misty sky which might produce here and there some whitish spots and bands.

This word "Milky Way," the name given to the phenomenon which causes this grandiose optical error, gives rise to some rather curious confusions. It establishes a fundamental distinction between the clusters of stars whose constituents are sufficiently bright and sufficiently separated to be seen as stars (the Pleiades, for example) and gatherings of stars which produce on our eye the sensation of "lacteal" light—although the two phenomena are identical in their nature; whilst the imperfection of our visual organ makes us class together from their appearances, but quite wrongly, gaseous nebulæ and the Milky Way.

The visual organ is not equally good in all men, and this has two results:—1st. What is "Milky Way" for one man is not so for another. 2nd. What is called "Milky Way" in one quarter of the heavens is not so called in another quarter.

Those who are not accustomed to raise their eyes in the evening higher than the gas lamps in the street scarcely know the Milky Way at all, never having bestowed upon it more than a fleeting glance. They are amazed that anyone succeeds in seeing in it more than a band, vaguely and uniformly luminous, and seen with difficulty.

The German astronomer Heis, whose piercing sight has become famous, counted 13 stars in the Pleiades, where even very good eyes see no more than "the hen with her five chickens":—

"Quæ septem dici, sex tamen esse solent."

Heis drew the Milky Way on his charts much larger than other observers. Without doubt he saw its light far outside ordinary limits. Searle has recently published his observations of several "Scattered branches of the Milky Way." Studying these attentively in exceptional atmospheric conditions, he succeeded in some parts in following these vague ramifications to regions near the galactic pole. The astronomer who has perhaps best examined the details of the Milky Way, Dr. Boeddicker, of Lord Rosse's Observatory, says that the background of the sky is nowhere uniformly illuminated, and Mr. Backhouse, of Sunderland, has also written recently:—"I do not think there is a uniformity of light in any part of the sky at a reasonable altitude; it is a question whether one may not say there are streaks and patches of Milky Way all over the sky."

All who are familiar with the appearance of the sky subscribe to this. Thus it would be possible to assert that there is no limit to the Milky Way. It would be more exact to say that, the word "Milky Way" hardly being a definable term, it does not seem possible to establish a distinction between vaguely luminous regions which are undoubtedly connected with the Milky Way, and those (the nebulous region of Coma Berenices, for example) where the relation with the galactic zone is at least very doubtful.

If those who enjoy excellent sight see in general more "galactic light" than others—as is natural—there are also cases where the want of good eyesight produces the effect of galactic light where ordinary eyes do not perceive it. A myopic person will see the Pleiades as a whitish spot, as a galactic spot.* And this brings us back to what I have just said, that "what is Milky Way for one person is not so for another." This is a consideration which must not be omitted when studying the *details* of the Milky Way on drawings made by different observers, for it will exercise a certain influence everywhere where there are groups or lines of stars on the verge of visibility to the naked eye. To give yet another example, which anyone can verify, the star 14 Aurigæ, and the neighbouring small stars (between ι Aurigæ and β Tauri) are seen separately in a very clear sky, but form a luminous line under ordinary atmospheric conditions (or for short-sighted persons). Such luminous lines or groups could thus produce the outlines of factitious luminous spots on the drawing; and similarly for exceptionally good eyesight, still feebler stars, grouped in other fashion, are at the limit of vision, and so we have thus one cause of error.

Another source of error and of divergence is to be found in the circumstance that to compare the light of vague galactic spots it is often necessary to pass the eye rapidly from one spot to another, and thus the luminous impressions accumulate, and are confused on the retina, and we think we see details which do not really exist.

I have wished simply to indicate several reasons why we can never expect *complete* accord between the drawings of the Milky Way made with the naked eye. There are others and even more important ones. And it follows, as it seems to me, that the main point is to fix first the great features of the galactic figure, not paying too much concern to the details, which are always uncertain, of doubtful ramifications. For the same reason it seems to me very desirable that all those who apply themselves to the naked-eye study of the Milky Way, so fascinating and so useful, should add to their drawings descriptions as detailed as possible.

There is no need to despair of ever arriving at a sufficient agreement. By no means. The causes of disagreement which I have just indicated have only a very limited effect. Even now, although we have only a very restricted number of drawings of the Milky Way at our disposal, its configuration can be settled, as to its major features, for a considerable portion of the zone. This is partly the result of the excellent work recently published by Mr Backhouse ("Publications of West Hendon House Observatory, Sunderland," No. II., 1902).

The differences which he establishes between his own observations and those of other observers are often more apparent than real†; in many cases they could be easily explained and eliminated. The important matter is to be able to compare with each other *a great number* of drawings made independently. I need only refer to what Mr. Maunder has said in his book ("Astronomy without a Telescope"), as the readers of KNOWLEDGE have no doubt seen, as to the service to the science which the friends of astronomy could render even without the possession of any instrument.‡

* It is true that these six stars would not certainly produce so brilliant an effect, even for normal eyesight, if their brightness were not enhanced by the luminous background produced by the myriads of stars on which they are projected.

† In the majority of cases they are due to imperfections in the reproductions.

‡ I may perhaps be allowed to note here that "charts for inserting the Milky Way" are to be had free of expense from the Editor of *Popular Astronomy*, or from Dr. A. Pannekoek, Observatory, Leiden.

Even in the matter of details, the agreement between different observations is very often remarkable. Between the two small, very near stars, π_1 and π_2 Cygni, in the extreme north of the constellation, the luminosity becomes slightly hollow towards the south. But this little, almost insignificant, detail, which really exists—it can be seen also on the photographs—is to be found in all the descriptions and drawings that I have examined.

There is, therefore, no need to be in despair that we shall never succeed—and even soon—in depicting in a definitive manner, and in fair detail, the *status presens*, of the visible galactic phenomenon. It would be a great accomplishment, and for two reasons. First, because it is always important to record as faithfully as possible in the storehouse of our observations all that nature presents to us; it is, so to speak, the first duty of all who study nature. And we can already see of what use such a document may prove to future astronomers Is it not strange that Ptolemy in his description of the Milky Way, so comparatively exact, recorded in the 138th year of our era in "The Almagest," says nothing whatever of the bright regions in Scutum? We cannot surely admit that all this region of the Milky Way was invisible 1800 years ago; more probably the copyists have made an omission. Nevertheless, if Ptolemy's description had come down to us in greater detail and better preservation, we should be in a position to-day to affirm that the phenomenon had been invariable in its general form throughout 2000 years. It is not impossible that very slow changes in brightness have come about in the case of most of the stars situated in the same region of the sky; they could be detected by a comparison of observations made at very distant epochs of time. Ought we not therefore, now, to make an effort and devise to posterity a document for such a comparison?

But another question is raised here. These efforts to obtain a representation of the Milky Way, as it appears to the naked eye, are they not useless in view of the enormous progress of celestial photography in late years—progress that does not seem to have yet reached its term?

I believe that this objection ought not to hinder us. Certainly the gigantic eye of the telescope and the perfected "retina" of the photographic plate are admirable instruments, and in particular stellar photographs are of the highest value. But at the same time let us not be ungrateful; our eye, the simple human eye, has also its advantages. Even the imperfection of the visual organ—and this is a very interesting point—enables us to attain one thing that photography is powerless to do: the impression of the whole. It embraces and registers in a single glance, in a single instant, everything that is presented to it. The photographic plate on its side is, at first insensible, it takes time . . . only it catches up again! It accumulates slowly, during consecutive hours, during whole nights if we wish it, and in gathering up its treasures of hidden light, it exposes to us stars that the greatest telescope can scarcely reveal. . . . Only these are not, so to speak, "photographs of the Milky Way," though they are often so called. They are photographs of stellar groups, more or less numerous, *in* the Milky Way. The optical phenomenon of the Milky Way evidently cannot be rendered by a process of this nature. If finally we find forming on the plates, spots analogous to the galactic spots, they spring from other causes; partly since the appearance of such an image viewed from a certain distance produces an optical illusion to our eyes comparable to that produced by the Milky Way.

The photographic process has errors of its own. The light of a star gives rise to, not a luminous point, but a little disk, which is far from being circular, especially near the edges of the plate, and in the case of fairly bright stars this can spread, and may "eclipse" the small stars near. And if we examine such a plate carefully, especially if we compare it with other plates which have been exposed for a longer time, we often find that the small luminous spots which are to all appearance but single stars, are in reality groups of stars close together.

A more serious drawback in celestial photography is that we cannot yet succeed in obtaining anything more than a narrow degree of uniformity. This is easily explained when we consider the diversity of the instruments, the condition of the atmosphere, etc. So far it has only been possible to remedy in but an insufficient manner this important obstacle, and at least for photographs taken by different people at different times and places, it comes about sometimes that two photographs of the same celestial region present considerable differences, even where care has been taken to bring the conditions into as much accord as possible. The enthusiasm is much moderated of those who a few years ago saw in imagination observations which were entirely "mechanical"—the astronomers being henceforth relegated to their desks.

I do not wish to dwell here on the difference between the actinic light of stars which alone affects the photographic plate and the light which impresses our eyes. This difference, and the variety between the two kinds of images which result from it, is enough of itself to establish the need for visual observations.

We might even find cause for astonishment that the appearances of "photographs of the Milky Way" and of drawings should sometimes show so great a resemblance*—and it probably proceeds from the fact that for the very faint, inferior magnitudes, the great mass of the stars in the Milky Way are nearly of the same spectral type.

I have thought it useful to enter somewhat in detail into a question that seems to me of interest, especially for naked-eye observers. In conclusion, I would like to say something about the relation to each other of the optical phenomenon of the Milky Way and of the physical phenomenon—the Galaxy or the galactic system. But it is a delicate question, where it is for the moment of importance to affirm nothing and to accept results only as provisional.

What are the stars which produce the optical phenomenon?

In the first place, is there not here something beside stars? Nebulosities, sometimes brilliant ones, are shown by photography to be present in many parts of the Milky Way; do they not play in it an important *rôle*?

But there is little probability that this is so. Evidently the rays emitted by these nebulosities are extremely actinic. That means that probably they make little or no impression on our visual organ. It is even possible to make a little experiment in this matter. For this I chose a very brilliant region of the Milky Way—between α and ξ Cygni. In the small chart annexed (Fig. 1) I have traced as accurately as possible the contours of the luminous spot taken from the drawings of Heis, Houzeau, Pannekoek, Boeddicker and my own. As might be expected, the divergences are fairly great; still the tracing on the whole differs so widely from the contours of the celebrated "America Nebula" which makes this region such a brilliant one on the photographic plate (*see* Dr. Max Wolf's photograph reproduced in this number of Knowledge), that I consider it established that even this nebula does not sensibly affect the human eye.

* A comparison between Chart I. of my "Voie Lactée dans l'hemisphère boréal" and Barnard's photographs of the regions between Altair and Scutum (*Astrophysical Journal*, I.) is very instructive from this point of view.

Let us then confine ourselves to the stars. Theoretically we might assert that all stars, however minute, exercise an influence on our retina—and, consequently on the drawing—provided that they are sufficiently numerous

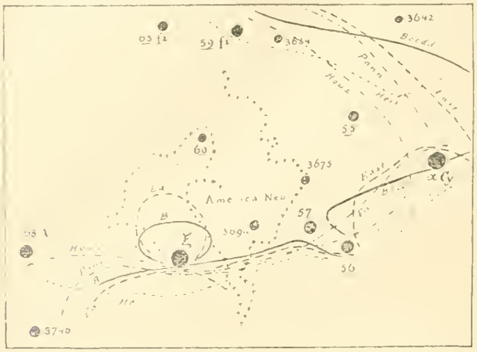


FIG. 1.—Drawings of a Galactic Spot (α—Λ Cygni) compared with the contours of a brilliant nebulosity. (The outlines of the drawings have been indicated by dotted lines, &c.; the form of the great nebula is indicated by little crosses. The numbers of the stars are those of Flamsteed (underlined), or of the General Catalogue.)

and sufficiently crowded. The stars visibly separate to the naked eye are naturally excepted. But in practice the question may be thus put: What order of brightness exercises the greatest influence?

Here, again, it is always the point to know if the stars form groups that are crowded enough. But taken in general, we can nevertheless show that the brilliant stars, at least to the 9th magnitude, do not exercise a *preponderant* influence. This was demonstrated some years ago by Plassman, by means of a chart on which he had drawn by gradations of colour a "theoretical Milky Way for Argelander's stars" (to about 9·5 magnitude), in giving naturally to the brilliant stars a greater part of the total light of a certain portion of the sky than to the faint. This chart—which was published in "Himmelskunde" (Freiberg, i., Br. 1898)—shows well a certain resemblance with the course of the Milky Way, but also considerable divergences. It is certain that these divergences are due to feebler stars than those in the Bonn Catalogue. Some time ago I tried to elucidate this question by comparing the distribution of the stars of different classes with the distribution of the galactic light in certain regions of the sky (KNOWLEDGE, August, 1895), and in a more recent paper I pushed this enquiry further.

In a very brilliant region of the Milky Way, to the south of γ Cygni (Fig. 2), I have taken a surface measuring 1° in declination and 4 minutes in right ascension (coordinates for 1855·0: $\alpha = 20h\ 2m.\ 30s.$ to $20h.\ 6m.\ 30s.$; $\delta = 36° + 37°$. A single star (25 Cygni, B.D. 3907, mag. 5·5 Arg.; 5·2 H.P.) is visible to the naked eye in this region. On a photographic plate by Prof Max Wolf, of Heidelberg, I have observed and classified as carefully as possible all the stars included in it, drawn with their estimated magnitude. They seem joined together on the drawing*—1760 are counted, classified as follows:

Estimated Mag.		Number of Stars.		Total light produced by each class.
7·6— 8·0	..	1	.	243
8·1— 8·5		6	...	923
8·6— 9·0		6	...	584
9·1— 9·5	.	17	..	1048
9·6—10·0		42	...	1639
10·1—10·5	...	61	...	1509
10·6—11·0	. .	103	...	1613
11·1—11·5	..	135	...	1338
11·6—12·0	. .	134	...	840
12·1—12·5		141	...	560
12·6—13·0		188	...	472
13·1—13·5		229		362
13·6—14·0	...	697	.	697
Total	...	1760		11,828

These magnitudes are only estimated; they cannot be identical with Pickering's scale, for example, and the limits cannot be constant. But in any case it is clear that about half the total light (the share of each class of stars in the total light has been indicated in the last column of the table, the brightness of a star of the first class having been taken as unity) is due to the magnitudes 9·6

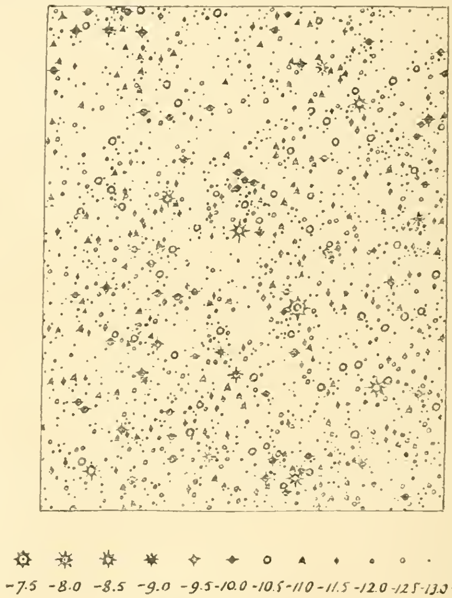


FIG. 2.—$\frac{1}{50000}$th part of the Sky: 1760 Stars.

to 11·5, or 9th to 12th, and that even large errors in the estimation do not sensibly modify this result; that neither the relatively bright telescopic stars (6th-9th mag.) nor the exceedingly feeble stars (12th-14th mag.) exercise any considerable influence in the production of the optical phenomenon of the Milky Way. A similar investigation in a region of the Milky Way much less brilliant leads to almost the same result.

* For particulars of these researches, I must refer the reader to my recent article "The Distribution of the Galactic Light, &c." in the "Verhandelingen de l'Akademie Roy. des Sciences des Pays-Bas, VIII., 3.

On the same area of the sky on which these 1760 stars are counted, there is but *one* visible to the naked eye; a short exposure gives 40. (Compare Mrs. Maunder's photograph reproduced in KNOWLEDGE, December, 1900; though, doubtless the negative would show a greater number of stars.)

If the entire sky were strewn as profusely with stars—though it is plain that is far from being so—photography would show us 90 millions of stars down to magnitude 14.

NORTH.

EAST.

WEST.

SOUTH.

THE "AMERICA" NEBULA IN CYGNUS

Photographed by Dr. Max Wolf.

But may we conclude that it will be the same in all the other regions of the Milky Way? Here again, though we must not positively affirm anything, I am inclined to believe that more complete investigations will not lead to very materially different results. Still we already know that the distribution of different stellar classes, in this connection, is not the same for different regions of the zone. Thus, when we treat of the "relative frequency" of stars of different magnitudes as we have done above for near γ Cygni, we can say that the mean brilliancy of stars in the Milky Way approximates much more nearly to the bright classes in the northern regions near Cepheus, whilst this mean magnitude is much feebler towards the south in the regions of Aquila and Scutum. I have tried to explain in former numbers of this magazine (KNOWLEDGE, 1902, July and August) for what regions these peculiarities of distribution appear to me of the greatest interest for leading us to conclusions as to the probable distance of parts of the Milky Way.

Rotterdam.

THE SURROUNDINGS OF THE "AMERICA" NEBULA.

By DR. MAX WOLF, F.R.A.S.

PHOTOGRAPHS of this fine nebula have been published not only by myself (KNOWLEDGE, 1902) but also within the last few months by Dr. Roberts and by Professor Barnard. On these occasions, however, only the nearest surroundings have been reproduced. Owing to the great interest of this beautiful object I have prepared a reproduction of a whole plate, showing the situation of the nebula in the thick cloud of the Milky Way, which is so striking to the naked eye as we look eastward from Deneb. On this reproduction we see much better the faint nebulous matter filling the dark channels between the stars to the east and west of the "America" Nebula. The great difference in appearance between the crowds of stars and the nebulous parts is very well seen. The most interesting parts seem to be the streams and clouds at the western side of "America" between the bright stars. The reproduction is of the same size as the original plate, and is made by contact printing only, and without any retouching. Scale:—One degree = thirty-five millimetres.

Konigstuhl, Heidelberg, February. 1903.

Letters.

[The Editors do not hold themselves responsible for the opinions or statements of correspondents.]

RARE CONDITION OF THE HUMAN HAIR.

TO THE EDITORS OF KNOWLEDGE.

SIRS,—If one examines closely the variations of the hair on many human subjects, interesting facts frequently appear. One of these I found lately on the hands of a man aged 23, whose skin was generally very hairy. The dorsal surfaces of his hands and fingers presented, in the usual places where hairs are found, groups of black points, and among these a very few stray hairs of ordinary length. On the dorsum of the hand the black points were only seen at the radial and ulnar borders, the surface between being clothed with hair of the usual kind. When one's finger was passed over these black points, against the proper slope of hair of the part, the skin felt quite smooth. Examination with a lens showed that the black points were shafts of hairs which did not project above the epidermis. The appearance was indeed more like that of the black dots so common on other parts of the skin, and due to acne, than like the ordinary worn-down appearance of hairs, and the man said that as far as his recollection went back he had noticed the black points to be just as they are now. I may add that no similar state of the skin and hairs was to be found on the feet. This condition of the human hair is very rare, and I have never met with it before. As far as it goes it supports the view that the worn-down bristly state of the hair on the digits, so often found in man, is due to a mechanical cause, viz., constant friction of the hair against external objects, and not to any true degeneration of man's hairy covering of which this is a small part. The phenomenon noted here, dating as it does from a very early period of life, tends to show that the worn-down state of the hair was inherited.

WALTER KIDD.

SOLAR ACTIVITY AND TERRESTRIAL MAGNETISM.

TO THE EDITORS OF KNOWLEDGE.

SIRS,—In a recent contribution to the *Astrophysical Journal* (November, 1902), the writer of the same, Mr. A. L Cortie, throws doubt on the observations made by Prof. Young at Sherman in 1872, and contends that the phenomena observed by Prof. Young do not stand in the relation of cause and effect, as regards some sharp twitches of the magnetic needle, apparently synchronous with several directly observed spectroscopic disturbances. I have always attached great importance to these particular observations of Prof. Young, who, needless for me to say, is a most conscientious and careful observer. His observations not only deal with a solar disturbance and *not with a spot as such*, but they incidentally favour the idea of a *sun-located* cause. Mr. Cortie, as I understand, takes up the position that spot-areas cannot be directly expressed in values of magnetic force. From this view I think hardly anyone will be prepared to differ, but that opinion does not necessarily include the displacement from the sun of the cause of the terrestrial magnetic disturbance. At any rate, many observational reasons point the other way. These I gave your readers in a letter on this subject in the December issue of KNOWLEDGE.

On looking the matter up again in Young's "The Sun," I come to the conclusion that to label Young's observations and deductions "coincidences" is, in my humble opinion, unjustified. At the same time it must be stated that Young himself leaves the matter pretty much an open question. Mr. Cortie tells me that if I did study the curves for the days in question I should modify my opinion. I went to examine the Greenwich observations, but was unable to find a record of the curves, and must, therefore, rely on the diagram given in "The Sun" as a faithful representation of the magnetic records of the two days. And there are, on August 3rd, 1872, three distinct solar paroxysms taking place at clearly defined time-intervals, each strictly simultaneous with the mechanically recorded magnetic disturbances. The diagrams do not evince sufficient general excitement to screen in the least the three distinct jerks of the needle. Contrary to Mr. Cortie's opinion, I consider, therefore, the case just cited as much more convincing than the one which took place two days later, in the proportion of three events against one. Mr. Cortie misses the point when he says of the second case that it was nothing unusual, because it occurred at the tag end of a magnetic storm. The point is that particularly strong outbursts on the sun were directly observed at a definite time and the magnetic recording instrument responded at that precise moment by distinct and pronouncedly sharp excursions. For this reason then is the case of August 3 stronger, inasmuch as this synchronism repeated itself three times within 3½ hours.

Let me add to the above, that Lord Kelvin's so-called theoretical proof of the sun's inability to raise a terrestrial magnetic storm has never brought a grain of conviction to my self-reliant mind, and therefore I do not feel called upon to look for electrified corpuscles outside the sun, which are credited by some as taking part in the intervention of the forces concerned. This is very much like robbing Peter to pay Paul, apart from the fact that the observational objections to which I have already referred are in no way satisfied by such and similar propositions. Be it also remembered, that one authentical case disposes of Lord Kelvin's "impossible" dictum. In my opinion, the whole process is one of "induction," and the amount of work to be done by the sun to raise a terrestrial magnetic storm is merely a question of the sun's electric potential where disturbances occur, and of electrical conductivity of the luminiferous ether between sun and earth, both utterly unknown quantities to Lord Kelvin.

ALBERT ALFRED BUSS

9, Grosvenor Square, Ashton-on-Mersey

CIRCULAR RAINBOWS.

TO THE EDITORS OF KNOWLEDGE.

SIRS,—In reading over the correspondence in your columns on "Rainbow" in the February, September, and October numbers of KNOWLEDGE, 1901, I thought it might be worth while mentioning one thing I have noticed about rainbows while at sea, that is, that under certain conditions the rainbow is seen as a complete circle. The conditions required are, the observer should be situated on a mast or something of small diameter which does not prevent the sun from shining on the rain falling in the vicinity; he must be at least about 50 feet above the sea level; the higher he is the more brilliant will the colour appear of that part of the circle projected on the sea. But I have found that at a height of about 150 feet, the colour of the part with the sea or the deck of the ship for a background is quite as brilliant as the colour in the part projected on the clouds, which forms the rainbow to an observer at the sea level.

Then as regards the sun's altitude; if it is over 42° then the whole circle is projected on the sea. I have seen this circle where the sun had an altitude of over 75°, but then the circle crossed the vessel's deck. Of course it could be seen with the sun in the zenith, but it would be almost impossible for it to be raining and the sun to be shining in the same spot where the sun is at that altitude.

Although I have spoken of this "rainbow" as a circle, it appears as a circle only when the sun's altitude is over 42°. When the sun's altitude is less than 42°, and part is projected on the sky and part on the sea, then it appears to be an ellipse, a line drawn from the centre of the bow proper to that part of the ellipse close to the observer forming the major axis. When there has been a secondary bow visible from the deck, I have often gone aloft high enough to see the primary as a complete ellipse, but have never seen any more of the secondary bow than was visible from the deck.

In writing this I may only be repeating what has often been noticed before, but I have never seen it mentioned anywhere. CHARLES C. DIXON.

Liverpool.

Obituary.

ANDREW AINSLIE COMMON, LL.D., F.R.S.

We much regret to announce the death of one who has done so much for astronomical science as Dr. Common, who died very suddenly at Ealing on June 2nd. He was born at Newcastle on August 7th, 1841, and eventually settled down in London as an engineer; but in addition to his business life, he devoted much time and energy to astronomy, especially to the construction of large reflecting telescopes. Early in life he possessed a 5½-inch refractor, and in 1876 he was observing with an 18-inch reflector; but not satisfied with this, he constructed a 3-ft. equatorial reflecting telescope, with a silver-on-glass reflecting surface. A slight delay was experienced in getting this instrument to work, as the first mirror burst into fragments, but in 1879 the second mirror was successfully mounted. Recognizing the value of photography, he had already applied it to obtain records of the Pleiades and other regions, but with this increased optical power he at once turned his attention to secure impressions of nebulæ, and it was with this instrument that he obtained the splendid photograph of the Nebula in Orion, gained an astronomical reputation, and won the gold medal of the Royal Astronomical Society. Other observations with the 3-ft. enabled an error in the ephemeris of Mimas, the satellite of Saturn, to be corrected. However, with 3-feet aperture the ambition of Dr. Common was not yet reached, for in 1880 he ordered a 61-inch disc of glass, and eventually successfully completed his 5-ft. reflector, which perhaps, with a newly-silvered mirror, is the most light-grasping instrument ever constructed, and although it never established the record that the smaller obtained, and has again recently secured at the Lick Observatory, yet it is doubtful if some of the unpublished photographs of Jupiter and Saturn taken with it have been surpassed.

Space will not permit mention of more than a few of the mechanical difficulties he overcame in these mammoth instruments—the successful silvering of large mirrors, the floating of the polar axis to reduce friction, and the slipping plate to correct clock irregularities.

He was elected a Fellow of the Royal Astronomical Society in 1876, and of the Royal Society in 1885, and was President of the former Society in 1895-6. He was an honorary LL.D. of St. Andrews, and filled many offices in connection with astronomy.

Of late years his energies had been largely devoted to the application of the telescope to gun-sighting, and he was so successful that the War Office and Admiralty had adopted his gun-sighting telescope. He had many other improvements in sighting apparatus in contemplation, and his death is not only a loss to the astronomical world, but to the nation.

Notes.

ASTRONOMICAL.—Prof. Barnard has recently published a very interesting account of observations of the south polar cap of Mars which he made at the Lick Observatory in 1892 and 1894. He considers the early supposition that the caps are accumulations of snow to be as good as any theory since put forward, and points out that they cannot be of any great depth or they would not be melted so quickly; they are probably a thin sheeting corresponding with the winter snow which extends to our own mid-latitudes and quickly disappears with the approach of summer. On some occasions portions of the cap were temporarily hidden, and there was good reason to suppose that the obscuration was produced by something of the nature of clouds, though the atmosphere seems to be much less dense than our own. The most striking phenomenon, however, was a projection from the edge of the cap, visible at the same point in both years, which was left behind as a bright strip as the cap diminished in size. This is probably a range of mountains, and was found to

have been previously observed by Mitchell in 1845, and also by Green, who gave the same explanation.

A series of very interesting photographs has been secured by Mr. H. K. Palmer with a slitless spectroscope specially designed for use with the Crossley reflector of the Lick Observatory. Among them are spectra of planetary nebulæ and Wolf-Rayet stars, but the most important are those of bygone "new stars." Nova Aurigæ, in 1901, when its visual magnitude was 13, showed four bright lines, and a comparison with earlier records shows plainly that the bright lines are growing weaker as compared with the continuous spectrum. Nova Cygni (1876), now about 15th magnitude, seems to have completely lost its nebular characteristics, the spectrum having become continuous. Mr. Palmer thinks it will now be possible to photograph the spectrum of any star that can be seen with the 36-inch telescope.—A. F.

BOTANICAL.—Visitors to Kew Gardens during the past few weeks may have noticed in the Succulent House some tall plants, having pinnatisect leaves, with long stiletto-shaped segments, and large terminal heads of bright pink flowers. This is a hybrid *Kalanchoe*, known as *K. kewensis*. In the March number of the *Annals of Botany* Sir W. T. Thiselton-Dyer made it the subject of one of his interesting "Morphological Notes." The hybrid originated at Kew, and besides being a beautiful plant of considerable horticultural value, it is remarkable in being a striking exception to the rule that a hybrid exhibits characters intermediate between those of the parents. The species from which the new hybrid was derived are the South Arabian *K. Bentii* and *K. flammea*, from Somaliland; the former has long entire stiletto-shaped leaves and white flowers, while in the latter the leaves are obovate or obovate-oblong, and the flowers orange-red. In the hybrid the leaves are not intermediate, but they approach in shape two other species of *Kalanchoe*, and, as the author observes, "the conclusion seems irresistible that we have a reversion to an ancestral character which exists elsewhere in the genus, but is latent in both parents." The deviation in the colour of the flowers is more easily accounted for. It is shown that in one parent the flowers have deep yellow chromoplasts in a pink cell-sap; in the other both chromoplasts and cell-sap are colourless. The hybrid, it is believed, has inherited the pink cell-sap of one parent and the colourless chromoplasts of the other.—S. A. S.

ENTOMOLOGICAL.—In KNOWLEDGE for September, 1901, there appeared an account of Flies and Midges that haunt the sea-shore. In a recent paper (*Arch. Zool. Exper. et Gen.* (4), Vol. 1, 1903, pp. 1-29, pl. 1), M. René Chevrel describes a very interesting new marine midge, which he has discovered at Saint-Briac (not far from St. Malo in Brittany), and named *Scopelodromus isemerinus*. Both sexes of this midge are winged, and possess short feelers with only seven segments. The larva lives among seaweeds and barnacles below the usual low-water mark, and, as the life-cycle of the insects occupies six months, the midges are only seen on the wing twice a year at the time of the equinoctial spring tides. It is no wonder, therefore, that they have remained unobserved for so long.

Meanwhile Mr. A. D. Imms records (*Trans. Liverpool Biol. Soc.*, Vol. XVII., 1903, pp. 81-6) the occurrence on the coast of the Isle of Man of *Clunio bicolor*, Kieffer, described a year or two ago from the French shores of the Channel. The presence of a second species of this most remarkable genus in the British Isles is noteworthy. Like *C. marinus*, Haliday (described in KNOWLEDGE, September, 1901), *C. bicolor* has a wingless female.

Parental care among insects is always a subject fascinating to naturalists, and a short paper by Mr. G. W. Kirkaldy (*Entomologist*, Vol. XXXVI., 1903, pp. 113-120) on "Maternal Solicitude in Rhynchota and other non-social Insects," with a full bibliography, is worthy of attention from all interested in the beginnings of family life among animals. Good evidence is brought forward for watchful care exercised by mother Saw-flies and Shield-bugs (*Pentatomidæ*) over their eggs and newly-hatched young, and Mr. Kirkaldy shows that the doubt thrown by Fâbre on the observations of DeGeer and others of maternal care among Shield-bugs is unwarranted, he having examined bugs of genera distinct from those upon which DeGeer's researches were made.—G. H. C.

ZOOLOGICAL.—In an article published in our columns a few years ago, Mr. Lydekker drew attention to the evidence in favour of an Asiatic origin for the aborigines of Australia, whose nearest relatives then appeared to be the Veddas of Ceylon. In a letter from Macassar (*Globus*, May 7th), the Messrs. Sarasin, who are travelling in Celebes, announce the discovery in the mountains of that island of a primitive people—the Toala presenting a remarkably physical resemblance to the Veddas. Although these people have now, for the most part at any rate, been considerably influenced in the mode of life by contact with the Buginese of the coast districts, there is decisive evidence that a short time ago they were cave-dwellers (as indeed are some of their number now), while within a century or so ago they were in the habit of using chipped stone arrow-heads and other weapons and implements. There can be little doubt that the Toala were the primitive inhabitants of Celebes, and that they were driven to take refuge in the mountains by the Malay invaders, with whom, however, they now hold a certain amount of intercourse. Assuming their affinity to the Veddas to be true, and it is scarcely likely that such a remarkable resemblance can be merely accidental, we have much stronger evidence than before as to the probable Asiatic origin of the Australian aborigines.

It is a common belief among both whalers and naturalists that when whales "sound," they descend to enormous depths in the ocean. Dr. W. Kükenthal estimates, for instance, that the larger members of the group commonly dive to a depth of fully a thousand yards; although the evidence on which this estimate rests is not given. In a memoir recently published in Belgium, on the scientific results of the Belgian Antarctic Expedition of 1897-99, Dr. Racovitza challenges this belief, and states that, in his opinion, one hundred yards is the maximum depth to which any whale can dive, and that many species cannot reach anything like that limit. He very pertinently asks why should whales want to go to such depths. All whales sound for the purpose of obtaining food; and in the profound darkness of one thousand yards what food could they get? Those species which feed on animalcules might perhaps obtain what they want. But how about the species which feed on fishes and cuttles? At a depth of a thousand yards they certainly could not use their eyes to detect non-luminous species, and we have no evidence whatever that they feed on the self-luminous deep sea fish and cuttles (if indeed there be any of the latter). On the contrary, the available evidence indicates that they feed on ordinary light-dwelling fishes and cuttles which live in much shallower zones.

But this is not all. It is known that the effects of a pressure of more than three atmospheres proves fatal to human life, and although we may believe that whales can stand treble this pressure, or nine atmospheres, which

would occur at about ninety yards depth, is it conceivable that they could resist the effect of ten times the latter pressure, or ninety atmospheres? Moreover, does it seem possible that a whale, whose body is only slightly heavier than water at ordinary pressure, could exert the muscular force necessary to propel that body to a depth of a thousand yards?

Whether the author has so strong a case in his contention that whales never sleep, demands further consideration. One of the arguments in favour of the constant wakefulness of cetaceans is that individuals will follow a ship for days, which they could not well do while asleep. Another is that whales—except occasionally a right whale or a sperm whale—are not found floating motionless on the surface, and reasons are given against the theory that they sleep at the bottom. But, it may be urged, if whales never sleep, they must have food at night, and be able to catch it, and what then becomes of the argument that they cannot capture prey in the dark ocean abysses? Moreover, it is difficult to imagine that an animal with such a highly organised brain as a whale can exist permanently without sleeping, especially when we remember that fishes sleep.

A very important work on the morphology of the mammalian brain—especially that of lemurs, both recent and fossil—has appeared in the *Transactions* of the Linnean Society. The author, Dr. G. Elliot Smith, has for several years devoted special attention to this subject, and in this memoir summarises the general results of his investigations. One point was the determination of the fundamental plan of mammalian brain-structure; a task of very great difficulty owing to the maze of convolutions of various types which have been superadded in the different orders. Especial interest attaches to the author's conclusions with regard to the affinities of the lemurs. The intimate connection between these animals and the monkeys and apes indicated by palæontological discoveries in Madagascar is fully borne out by Dr. Smith's investigations. It appears, however, that while the lemurs originally advanced a considerable distance along the general line of evolution of the Primates, they subsequently degraded; a fact which accounts for the wide divergence of the modern representatives of the two groups.

The restoration of a most extraordinary reptile—namely *Embolophorus dollorianus*, from the Permian strata of Texas—is attempted by Mr. E. C. Case in the February number of the *Journal of Geology*. The peculiarity of the creature is that the vertebræ carry very tall vertical spines, which in the middle of the back are equal in length to the entire trunk, and nearly double the height from the ground to the back-bone. That this bony framework carried a thin covering of skin, and was thus something like an enormous back-fin, may be considered certain; but the use of such a remarkable structure has yet to be explained.

In the April number of the *Proceedings* of the Zoological Society the Revd. F. Jourdain draws attention to the circumstance that the second instance of the occurrence of Bechstein's bat (*Myotis bechsteini*) in Britain was recorded in the *Zoologist* for 1888, on the evidence of a capture in the New Forest in 1886. Consequently the announcement made in the *P. Z. S.* for 1901 of the *second* occurrence of the species in Britain should really have been the *third*.

In a recent issue of the *Annals and Magazine of Natural History* Mr. G. A. Boulenger adduces reasons to show that that fishes, instead of being allies of the cod family, are really related to the John Dory. From the shape of the latter fish this is a much more probable supposition.

British Ornithological Notes.

Conducted by HARRY F. WITHERBY, F.Z.S., M.B.O.U.

Ornithological Notes for Norfolk for 1902, with References to some Occurrences in other Counties. By J. H. Gurney, F.Z.S. (*Zoologist*, April, 1903, pp. 121–138).—Mr. Gurney here gives his usual yearly interesting notes on the birds of East Anglia. The autumn of 1902 seems to have been chiefly remarkable for a large migration of Rooks throughout October. The following rarities were recorded from Norfolk during the year, viz.: Scops Owl—April; Roseate Tern—May and June; Caspian Tern—July; Roller, Aquatic Warbler, and Barred Warbler—September; Lesser Grey Shrike and Porphyris—October; Glossy Ibis—November; and Little Bustard—December. Mr. Gurney can unfortunately give us no good account of the Great Bustards which were imported and turned down in Norfolk in 1900.

On the Position occupied by the Legs of Birds during Flight. By G. E. H. Barrett-Hamilton (*Zoologist*, April, 1903, pp. 139–140).—It appears from this interesting article that whereas most passerine birds carry their legs bent forward in flight, other birds carry them pointing backwards, while some birds such as Kites and Gulls and certain Hawks, have the power of varying the position of their legs without interfering with their flight. Capt. Barrett-Hamilton is of opinion that in many birds, and especially in those with short tails, the legs are of great and constant assistance in flight.

The Birds of N.W. Wales and the opposite Counties of Ireland. By H. E. Forrest (*Zoologist*, May, 1903, pp. 176–181).—Mr. Forrest here compares the avifauna of Merioneth, Carnarvon and Anglesey to that of Dublin and Wicklow. The result is that most of the summer migrants occurring in Wales are very rare or absent from Ireland, while the resident birds are also very different in the two areas. For instance, the Marsh Tit, Nuthatch and Tawny Owl, although common in the Welsh counties are unknown in Ireland, and the Sparrow, Carrion Crow, Spotted Woodpecker and Green Woodpecker are of rare occurrence in the Irish counties. On the other hand the Siskin, Crossbill and Hooded Crow are more common in Ireland.

The Status of the Goldfinch in Britain (*Zoologist*, April, 1903, p. 152; May, 1903, p. 190).—Observers from various counties here continue to record their observations upon the status of the Goldfinch.

On the Variation of the Bean Goose. By Einar Lönnberg, C.M.Z.S. (*Zoologist*, May, 1903, pp. 164–169).—In this article the author details his examination of a number of specimens of the Bean Goose, and gives evidence for the conclusion that the characters used by Mr. Frohawk (*see* KNOWLEDGE, 1902, p. 254) are too variable to warrant the separation of the Bean Goose into two species (*Anser segetum* and *A. arvensis*).

All contributions to the column, either in the way of notes or photographs, should be forwarded to* HARRY F. WITHERBY, *at the Office of* KNOWLEDGE, 326, *High Holborn, London.

Notices of Books.

"A MANUAL OF PALÆARCTIC BIRDS." By H. E. Dresser, F.L.S., F.Z.S. Part I. Published by the Author at 3, Hanover Square, W. 12s. 6d. net.—This is the first part of a work long expected by ornithologists. The second and concluding part, we believe, is to be published very shortly. The work is practically an abridgment of Mr. Dresser's well-known "Birds of Europe." It is very conveniently arranged, and much information is given in a very small space. After a brief synonomy a description of the species is given, and in this Mr. Dresser has been wise in giving as far as possible the points in which one species differs from its nearest ally rather than a long and detailed description. We are then given the range of the species, and a few words about its habits and nest and eggs. The book will be found to be very useful to ornithologists, and especially to those that travel, but Mr. Dresser seems to have relied to a great extent on his excellent work in the "Birds of Europe," and has not brought his present Manual consistently up to date. The range of the various species dealt with is thus sometimes rather incomplete, and although Mr. Dresser has admitted many sub-species, he has also omitted many which, in our opinion, are as qualified to rank as distinct races as many of those which he has admitted (*e.g.*, *Prinia gracilis lepida*, *Argya buttoni*, *Parus lugubris dubius*).

But Mr. Dresser's Manual is not intended for the systematist. To the traveller it will certainly be of much use, although we wish that the author had directed attention to many more geographical variations than he has done.

"The Journal of the Quekett Microscopical Club," April, 1903. (Published by Williams & Norgate, 14, Henrietta Street, Covent Garden, W.C.) — This journal is published bi-annually, and contains the proceedings of this popular Microscopical Club, which meets at 20, Hanover Square, on the first and third Fridays in each month. This Club has always been particularly strong in entomological and pond-life work, and several of the papers—which are admirably illustrated—deal with aspects of these subjects. Special interest attaches to the annual address of Mr. George Massee, F.L.S., V.M.H., the president of the Club, on "Fermentation and Putrefaction," on which, and allied subjects, he is a distinguished authority. In addition, there are reviews of certain books on microscopy. Those microscopists who may not be members of the Quekett Club would certainly find many items of interest and value in this admirably-conducted journal.

"Journal of the Anthropological Institute for 1902."—We have been favoured with a copy of this journal (Vol. XXXII.) for the second half of 1902. It commences with the Huxley Lecture, in which Dr. D. J. Cunningham discourses on "right-handedness and left-brainedness" in man. Physiological experiments have shown that a certain area on each side of the brain is connected in some way or other with regulating the movements of the arms; the left side of the brain controlling the right arm, and *vice versâ*. This being so, it was natural to expect, in correlation with the general prevalence of right-handedness in man, that the left "arm-area" of the brain would be more developed than the right. The author has found that a certain depression in this area is deeper on the left than on the right side. That this is in any way associated with right-handedness, or with the localisation of the active speech centre in the left side of the brain, he is, however, not prepared to urge, because the same condition obtains in apes. This would be no impediment to the acceptance of the explanation by those who believe that apes are also right-handed; but Dr. Cunningham cannot persuade himself that those animals are really dextrorsal. Nevertheless, he is convinced that he is on the true track to explain the prevalence of right-handedness in man. In the course of his lecture the author mentions that he sees no reason to believe in the absence of right-handedness in pre-historic man owing to a preference for drawing animals with their heads turned in one direction. In this connection it may be mentioned that the author persists in the old error of calling the bison the aurochs.

Among many other interesting articles, we have only space to refer to the one by Messrs. Annandale and Robinson on the anthropology of the Malay Peninsula, which is illustrated with photos of that puzzling race, the Semangs of Perak. The authors believe that Semangs and Sakais contain a Mongoloid element distinct from that of the modern peninsular Malays; but, unfortunately, they do not favour us with any definite opinion as to the Negrito affinities of these people, as indicated by the frequent occurrence of more or less distinctly frizzled hair.

"Handbook of Climatology." By Dr. Julius Hann. Translated by Robert De Courcy Ward. (Macmillan.) 12s. 6d. net.—It is commonly said that meteorology consists of volumes and tables of uninteresting figures that only experts can understand. It is further complained that few attempts are made to discover the inner meaning of the accumulated observations with which the shelves of most weather offices are congested. In this book, however, a notable and successful attempt has been made to put life and meaning into some of these arid statistics; and it may at once be said that the result is one of the most interesting books that the subject of climate has so far inspired. The book treats of climate as distinguished from weather, for nowadays the two terms are differentiated. Dr. Hann calls weather only one phase in the succession of phenomena whose complete cycle, recurring with greater or less uniformity every year, constitutes the climate of any locality. Climate is the sum total of the weather as usually experienced during a longer or shorter period at any given season, and it is with this latter branch of meteorology that Dr. Hann deals. Certain changes have been made by the translator in this English edition of Dr. Hann's book, which was originally published in 1883 under the title of "Handbuch der Klimatologie," but they are changes that have greatly increased the usefulness of the work. The book has been especially arranged for the use of teachers of scientific climatology, and as it contains ample references to other works on the same subject, and also a very convenient classification of the different sections and chapters, a teacher with it at his hand should have little difficulty in arranging a useful course of study. Since the teaching of meteorology has been much neglected in British schools, such a publication should stimulate an interest in the subject. Probably the most informing section will be considered by many readers to be that which deals with mountain climates. This subject is treated exhaustively in a discussion that no one who desires to know the lines of investigation followed by modern meteorologists in this very important branch of climatology can afford to overlook. The thanks of those who do not read German are due to Mr. Ward for so ably translating the book for them, and it is to be hoped that he will find an early opportunity of introducing English readers to more of the same author's works.

The Burlington Magazine for June contains an admirable editorial appeal for the preservation of ancient buildings by the State. The recent sale of Clifford's Inn has brought this question once more to the front, and we gladly associate ourselves with the Editor's appeal to the London County Council to acquire Clifford's Inn from its new owner while there is yet opportunity to do so. But the question is really one for His Majesty's Government, and we hope some Member of Parliament may be induced to make it his own, and remove the reproach that we share at present with Russia and Turkey, of being without any legislation for the preservation of our ancient historical buildings.

BOOKS RECEIVED.

Mathematical Crystallography and the Theory of Groups of Movements. By Harold Hilton, M.A. (Oxford: Clarendon Press.) Illustrated. 14s. net.

Among the Night People. By Clara Dillingham Pierson. Illustrated by F. C. Gordon. (Murray.) 5s.

The Religious Sense in its Scientific Aspect. By Greville MacDonald, M.D. (Hodder & Stoughton.) 3s. 6d.

Central Europe. By Joseph Partsch, PH.D. (Heinemann.)

Growth and Direction of our Foreign Trade in Coal during the last Half Century. By D. A. Thomas, M.P. (Royal Statistical Society.)

Smithsonian Physical Tables. By Thomas Gray. (Washington: Smithsonian Institution.)

Superstition, Magic, and Medicine. By Walter E. Roth, B.A., M.R.C.S. (Brisbane: G. A. Vaughan, William Street.)

Radiant Energy. By R. W. O. Kestel. (F. Cockington, 3, Mentone Road, N.) 2s.

The Service of Man. By Cotter Morison. (Watts.) 6d.

Watkins' Manual. (Hereford: Watkins' Meter Co.) 1s. net.

Adventures of Lyderic, Count of Flanders. By Alexandre Dumas. (Gowans & Gray.) 6d. net.

Field Studies in Natural History: Programme of Summer Rambles, 1903. (Essex County Education Committee.)

Commerce of Latin America. (Philadelphia Commercial Museum.)

Subject List of Works on Architecture and Building Construction in the Library of the Patent Office.

Report of the Committee on Mathematic Science for 1902. (Washington: Philosophical Society.)

"Via Indo" Telegraphic Social Code. Compiled by Robert T. Atkinson. (Via Eastern Code Company, Limited.) 5s. net.

Conférence Astrophotographique Internationale de Juillet, 1900. (Institut de France, Académie des Sciences.)

Variation in the Milk of a Dairy Herd. By T. S. Dymond, F.I.C., and B. W. Bull, N.D.A. (Essex Education Committee.)

Notes from the Royal Botanic Garden, Edinburgh, 1901. (Edinburgh: Oliver & Boyd.) 9d.

Veterinary Journal, June, 1903. 1s. net.

Astrophysical Journal, May, 1903. $4.

Scientific Roll, May, 1903. 1s.

Technical Arithmetic and Geometry. By C. T. Millis, M.I.M.E. (Methuen.) 3s. 6d.

A Junior Geometry. By Noel S. Lydon. (Methuen.) 2s.

The Cloud World: Its Features and Significance. By Samuel Barber. (Elliot Stock.) 7s. 6d.

The Year Book of Photography and Amateur's Guide, 1903. (*Photographic News* Offices.) 1s. net.

Catalogue of Photographic Apparatus and Materials. (City Sale and Exchange, Fleet Street.)

Booklet on "Tabloid" Photographic Chemicals. (Burroughs, Wellcome & Co.) Free.

"MOLECULES AND HEAT."*—A CRITICISM.

By Edwin Edser, A.R.C.Sc., F.Ph.S.

As the result of experiments carried on for a number of years, Mr. Hovenden claims that molecules can easily be seen by the unaided eye. Nothing could well be more startling than such a claim; it is proposed to examine briefly the grounds on which it is based. It may at once be said that Mr. Hovenden is perfectly honest in the statement of his case, and some of his experiments are worth repeating. Further, for an untrained observer, he sometimes notes the essential conditions of a phenomenon with commendable sagacity, although his explanations, as will be shown, are often of a very partial character. Personally, I have to thank Mr. Hovenden for his courtesy in showing me a number of his experiments, and explaining his views thereon.

Let us take a thin glass flask partially filled with a liquid, such as water, spirits of wine, &c., and focus the rays from an arc lamp at a short distance above the surface of the liquid. After gentle heating, a large number of small spherical bodies are seen floating about in the space above the liquid. Mr. Hovenden claims that these small spherical bodies are molecules of the liquid; he further defines a water molecule as a spherical body composed of *a great number* of atoms of oxygen and hydrogen in the proportion of one of the former to two of the latter. At first sight, therefore, it would appear that a water molecule, as defined by Mr. Hovenden, is indistinguishable from a small drop of water composed of a great number of the generally accepted molecules, each comprising one atom of oxygen and two atoms of hydrogen. Mr. Hovenden has, however, been struck by the fact that whereas a small drop of water, when cast up from the surface of the boiling liquid, is seen to quickly fall back again, yet the small particles mentioned above exhibit no observable tendency to gravitate, but slowly circulate, in swirls and eddies, in the space above the liquid. The accepted explanation of this depends on the fact that a gas or liquid exerts considerable friction on very small particles, which are thus unable to sink quickly; for similar reasons, muddy water clears very slowly when at rest, and more slowly still when in motion. We may, however, for the moment forget this, and consider Mr. Hovenden's explanation, which is that the small particles seen floating above the liquid were invisibly small when within the liquid, but during heating they absorbed the ether (which is supposed to be an anti-gravitating fluid), and expanded to visible dimensions, at the same time acquiring anti-gravitative properties. Mr. Hovenden has noticed that these particles are only to be seen when there is cold air in the flask. To most observers this would suggest that their presence demands conditions favourable to condensation. Mr. Hovenden, however, proposes the explanation that, when cold air is not present, the particles become invisible, just as finely-divided glass particles, which form a white flour-like powder in air, become almost invisible when mixed with water. When the liquid is caused to boil, and air is expelled from the flask by the vapour given off, the space above the liquid appears absolutely empty. "But," says Mr. Hovenden, "the flask is full of these spheres, for they issue out of the flask as steam." This is begging the question. The particles may truly be seen leaving the mouth of the flask, but this is perfectly consistent with the orthodox explanation that the interior of the flask is filled with aqueous vapour, the invisibly small molecules of which are comparatively widely separated from each other. At the mouth of the flask the vapour mixes with the cold dust-laden air of the room, and condenses into small water droplets.

Mr. Hovenden also fills spirit lamps with various liquids and concentrates the electric light on the wicks. In each case a stream of small particles is seen rising from the wick into the air, and these particles are claimed to be molecules. If the lamp is filled with methylated spirit, the stream of particles leaving the wick becomes bright, almost resembling a flame. This experiment is a very pretty one, and might be found useful to teachers, as showing the effects produced by the absorption of radiations. Mr. Hovenden's most striking experiment, however, consists in lighting the spirit lamp and placing the *flame* in the focus of the electric light. Particles, similar to those formerly described, but much less numerous, are seen in the interior of the flame, and Mr. Hovenden claims that in this case condensation is necessarily eliminated. Careful examination shows that the particles are visible only near the boundary between the luminous mantle of the flame and the non-luminous central core. This core is known to be cold, so that once more we have the conditions that the particles are formed only where the heated vapours have the opportunity of becoming cooled. It may be admitted that condensation occurring under the above is somewhat surprising, and Mr. Hovenden's observation is certainly of considerable interest.

I cannot see that Mr. Hovenden has given us any experimental proof that the particles seen in the above experiments are molecules, and not small droplets of condensed liquid. To disprove the theory which he proposes, it is only necessary to compare his fundamental conception with the results of experiments. He considers that a solid consists of invisibly small spherical molecules, in contact with each other. When the solid is heated, each molecule absorbs "ether," and expands as a soap bubble does when air is forced into it. This absorption of ether, and the consequent expansion of each molecule is considered to be essential to a rise of temperature. Of course such a theory labours under all the difficulties that beset the old caloric theory; indeed, writing "caloric" instead of "ether," in Mr. Hovenden's theory, we go back to the opinions of the early part of the nineteenth century, and Davy's experiments appear to disprove one as conclusively as the others. But Mr. Hovenden's theory can be disproved on other grounds.

If a rise of temperature is necessarily connected with an expansion of the molecules of a body, then *all* substances must expand when heated. Now a piece of glass rod, when heated to redness, expands so much that, on plunging it into cold water, it is shivered to fragments by the sudden contraction. So far facts are in accordance with Mr. Hovenden's theory. But a rod of fused quartz (more strictly speaking, fused silica) can be heated to a white heat, and then plunged into liquid air without the slightest danger, or any signs of an appreciable change of dimensions occurring. It can scarcely be claimed that, during these operations, the temperature of the fused silica does not alter; heat certainly leaves the rod when it is plunged into the liquid air, and causes the latter to boil violently. On the other hand, experiment shows that during cooling, a slight contraction which occurs at one stage is compensated for by a slight expansion at another stage, so that at the low temperature the dimensions of the rod are the same as at the higher temperature. If the molecules are in contact, it also follows that the dimensions of a molecule are the same at the low as at the high temperature. Thus a change of dimensions does not always occur when a body is heated.

If further evidence were needed, we might instance the contraction of water as it is heated from 0° C. to 4° C.

Mr. Hovenden has further attempted to explain the heat of chemical reactions in terms of his theory. When

* "On Resolving the Molecule and Seeing It." "What is Heat? A Peep into Nature's Most Hidden Secrets." By Frederick Hovenden, F.L.S., F.G.S., F.R.M.S.

hydrogen and oxygen combine to form water, the volume of the latter is less than that of the gases, and it is assumed that the atoms shrink, expelling the ether (or heat) from their interiors. From this instance Mr. Hovenden generalizes, and obtains the law that when two substances combine to form another substance, the original volumes of the constituents being together greater than the volume of the product, ether is expelled, producing a rise of temperature; when the original volumes of the constituents were together less than the volume of the product, ether is absorbed, and the surroundings are cooled. In some cases where the reaction occurs in air, and the results are not those anticipated, it is claimed that the air molecules are squeezed or expanded, as the case may be. It is, however, easy to disprove this theory, in a manner that leaves no loophole for escape. Take a cubic centimetre of gunpowder, place it in a strong steel cylinder of (say) 1000 cubic centimetres capacity, and thoroughly exhaust the cylinder. On exploding the gunpowder the constituents, which originally occupied a volume of 1 c.c., now occupy a volume of 1000 c.c., so that, on Mr. Hovenden's theory, each atom has expanded to 1000 times its original volume. Nevertheless, the resultant gases are found to be heated. The heat (or ether) absorbed by the atoms cannot have been taken from the cylinder, since the latter is certainly no cooler than before. Where, then, has it come from?

Thus we see that, starting from phenomena which anyone may observe, Mr. Hovenden has reached conclusions which, far from possessing an advantage over the accepted theories, are positively at variance with well-known phenomena. In criticising Mr. Hovenden's views, it has been found unnecessary to appeal to any other theory, except to show that the phenomena observed are capable of an independent explanation. As a result, it appears that if we possessed no physical theories at all, and were offered the above theory by Mr. Hovenden, we should be logically forced to reject it as inconsistent with itself, and with the greater part of our experimental knowledge.

FAMILIAR BRITISH WILD FLOWERS AND THEIR ALLIES.

By R. LLOYD PRAEGER, B.A.

IV.—THE COMPOSITÆ.

THE *Compositæ* form the largest Natural Order of flowering plants found upon the globe. About one-tenth of the whole phanerogamic flora may be referred to this group. They are of world-wide distribution, though their number varies largely in different countries. Thus Humboldt estimates that they form one-half of the phanerogamic flora of the tropical regions of America, and Presl states the same for Sicily; on the other hand, they formed only one twenty-third of the collections of plants made by Smith in West Africa near the Congo. In the British Isles they form about one-tenth to one-twelfth of the flora, the uncertainty as to exact proportion arising from the difference in the treatment which botanists accord to the hundred and more British "species" of Hawkweeds.

The character by which these plants are most readily recognized, and from which they derive their name, is the grouping of their flowers into dense, usually flattish, heads, surrounded by a ring of small leaves which fulfil the function of the sepals of an ordinary flower. In my last article, we saw how in the *Umbelliferæ* the numerous small flowers are gathered together, so that the whole forms a most conspicuous inflorescence; but in these plants each flower is stalked, and each group of flowers (umbellule) usually is again stalked; whereas in the *Compositæ* the flowers are unstalked (sessile), and are seated tightly on the flattened top of the flower-stem (receptacle). A much closer approach to the *Compositæ* we may study in the Scabious family (*Dipsaceæ*), of which the Devil's-bit (*Scabiosa succisa*) and Teasel (*Dipsacus sylvestris*) are familiar examples. Here, as in the *Compositæ*, the flowers are sessile and set on a swollen receptacle, and surrounded by an involucre of small leaves. From this nearly related Order, *Compositæ* may be readily distinguished by the stamens, of which the anthers join together to form a ring round the style; and by the erect, not pendulous, ovule. That the flower-form of the *Compositæ* is an eminently efficient form would appear from the vast number of its species, and from the immense profusion of individuals—in our own country, of the Daisy and Dandelion, for instance. And truly, these flower-heads strike one as being in the highest degree efficient.

1 2

FIG. 1.—Ray-flower and disk-flower of the Daisy (enlarged).

Examine a common Daisy. The yellow button-like *disk* is composed of a myriad of small perfect flowers, with yellow five-cleft tubular corolla, and ring of fused stamens surrounding the pistil. Of calyx we find hardly a trace; the close packing of the flowers leaves no room for it, and renders it unnecessary as a protective structure. In the *Compositæ* the calyx is usually reduced to a few hairs, which often play a valuable part in aiding seed-dispersal, as we shall see, by growing as the fruit ripens into a feathery plume or *pappus*, which acts as a parachute. The marginal or *ray* flowers of our Daisy have no stamens—are female; and their corolla is white, and greatly expanded in an outward direction—the only direction in which there is room for expansion. These ray-flowers, in fact, are largely useful in *advertising* the otherwise inconspicuous flower-head. Similar devices we have already noted in the wild Guelder-rose; and we may compare with these such flower-heads as those of the little Cornel (*Cornus suecica*) and the Astrantias, in which the flowers are surrounded by a ring of coloured *leaves*, which serve the same purpose. Finally, our Daisy head is surrounded by a close-fitting double ring of small leaves, the *involucre*, which encloses the whole in bud, and plays the part that a calyx usually plays in a single flower.

This vast Order may be divided into several well-marked groups. The *Corymbiferæ* include the genera which, like the Daisy, have a disk and a ray, and other rayless allied forms; the *Cynarocephaleæ*, which include all the Thistle-like forms, have the style swollen, and no ray; the *Ligulifloræ*, which form the best-marked group, have all the flowers *ligulate* (or shaped like the ray-flowers of the Daisy), as the Dandelion; while the *Labiatifloræ* include a few foreign genera, mainly South American, in which corolla of the central florets is two-lipped.

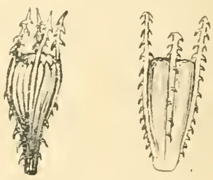
The *Compositæ* yield us some of our handsomest garden plants, such as Chrysanthemums, Dahlias and "Cinerarias," the latter being cultivated varieties of species of *Senecio*, introduced from the Canary Islands; also the Sunflowers and their allies, Asters, and various kinds of "Everlasting." Among vegetables, the best known are Jerusalem Artichokes (the tubers of *Helianthus tuberosus*), and Artichokes (the receptacles and involucral scales of *Cynara Scolymus*). Many species are aromatic, astringent, or narcotic, but for so vast a number of plants, comparatively few are used by man.

To sketch even the comparatively few British representatives of the *Compositæ* within the limits of a single article were an impossible task. The list of *Compositæ* in

the "London Catalogue of British Plants" numbers 234 species though it must at once be pointed out that this total includes no less than 104 "species" of that perplexing genus, *Hieracium* (Hawkweed); if we wish to institute comparisons, this 104 species must be reduced to say ten to twenty leading forms. Even with such a reduction, the British *Compositæ* are still sufficiently numerous, and offer a wide diversity of plant-forms; but certain limitations may be noted with regard to them. Firstly, all are herbaceous; among the many British species neither tree nor shrub is found. And secondly, despite the great variety of habitat which they effect, all are terrestrial forms; some few may be found in wet marshes, but none are aquatic. For the rest, they occur in all situations, from salt marshes on the coast to the tops of the highest mountains, and they assume all forms, from tiny annuals to great perennials like the Butter-bur, with leaves which may attain six feet in height.

We have already referred to the three sections into which our species may conveniently be divided, exemplified respectively by the Daisy, Thistle, and Dandelion. Let us now glance more particularly into the native species which fall under each of these groups, and note their more prominent features. The Daisy group, or *Corymbiferæ*, includes not only all the Daisy-like flowers, with a disk or centre of close-set perfect blossoms, and a ray or margin of flowers with a corolla prolonged into a conspicuous flattened limb, often of a different colour to that of the disk-flowers; but also a number of species without the showy ray, such as Butter-bur (*Petasites*), the pretty Cudweed group (*Antennaria*, *Gnaphalium*, and *Filago*), the Mugworts (*Artemisia*), Tansy (*Tanacetum*), Sea Cudweed (*Diotis*), and Bur-Marigold (*Bidens*). But the presence or absence of ray-flowers is not an important or even a constant character. For instance, some of the Senecios have a ray, others none. Of these, the rayed Common Ragweed (*S. Jacobæa*) and the rayless Groundsel (*S. vulgaris*) will stand for examples; yet the Ragweed often is devoid of a ray, especially on coast sand-hills, where the rayless form is often the prevailing one, and the Groundsel may often be found with ray-flowers well developed. The Common Bur-Marigold (*Bidens cernua*), normally rayless, sometimes produces a ring of yellow ray-florets, which makes of this somewhat dull flower a quite showy plant. Of stem forms, our *Corymbiferæ* offer no great variety, the stems being usually herbaceous, upright, and branched. The genera *Petasites* and *Tussilago* (Butter-bur and Colt's-foot), however, offer good examples of strong underground creeping stems. These are possessed of much vitality, which makes the Colt's-foot a very difficult weed to eradicate. Similarly, the Winter Heliotrope (*Petasites fragrans*), a plant introduced from Sicily for the sake of its fragrant flowers produced in mid-winter, which has now run all over the country. From its interlacing, far-creeping tangle of subterranean stems, a growth of kidney-shaped leaves is produced, so dense as to exterminate every native herb which it encounters. The Flea-bane (*Pulicaria dysenterica*) and Sneezewort (*Achillæa Ptarmica*) have likewise far-creeping underground stems. The leaves of the Daisy group offer much variety. Especially noticeable is the development of grey felt in those species whose habitat renders it necessary to avoid too great transpiration. The most remarkable example of this is the rare Sea Cudweed (*Diotis maritima*), a plant of dry gravel-beaches, the stems, leaves, and even involucres of which are clothed with dense white felt, giving the plant a most remarkable appearance. We may note the same development of felt in the Cudweeds, all plants of dry places. The Sea Wormwood has its home habitat in salt marshes, and consequently finds it necessary to economise water; it also has its fine-cut leaves and its stems and inflorescence uniformly covered with grey felt. The Golden Samphire (*Inula crithmoides*), which has its habitat on sea rocks, has developed exceedingly fleshy leaves, like many of the halophytes, or salt dwellers; like the Samphire, after which it is called, these juicy leaves are deliciously aromatic. It is perhaps among some of the larger members of the Daisy group that the composite inflorescence attains its greatest beauty and perfection. Examine such a flower-form as the Ox-eye Daisy. First we have the close-lapping scales of the involucre, securely enclosing the whole, and protecting it when in bud. Then the splendid ring of ray-flowers, whose object is to render the inflorescence more conspicuous. Thus we find these enormously-expanded corollas often assuming a tint other than that of the main mass of flowers—white, when the disk is yellow, as in the Ox-eye; in other species blue, or purple, or yellow, accompanying a yellow or greyish disk. These ray-florets have sacrificed their perfection as flowers for the purposes of advertisement, and are usually devoid of stamens, or sometimes devoid of both stamens and pistil. Finally we have the dense mass of disk-florets, all perfect, producing a quantity of minute fruits. As for the fruit of the *Corymbiferæ*, a large number rely on wind carriage, and the calyx-segments take the form of hairs, which grow into a more or less perfect parachute to aid in transporting the comparatively large fruit to pastures new. These parachute-fruits we know well in the Groundsel, Colt's-foot, Hemp, Agrimony, and Sea Aster. A large number of other genera, among them the Daisy, Ox-eye, Chamomile, Mugwort and Yarrow, are devoid of conspicuous fruit-appendages of this kind, and apparently secure by the swaying of their stems a seed-dispersal sufficient for their needs. The Bur-Marigold derives its name from the fact that its fruits are provided with spines (the altered calyx limb) armed with reflexed hooks; when ripe the fruits easily attach themselves to the coat of any passing animal, and secure wide dispersal thereby.

FIG. 2.—The Golden Samphire. (Half natural size.)



a b

FIG. 3.—Fruits of Bur-Marigold. *a*, *Bidens cernua*; *b*, *B. tripartita*.

Turning now to the Thistle group or *Cynarocephaleæ*. Here we meet with perhaps the handsomest of our *Compositæ*—the Thistles, which must rank among the most beautiful of all the plant-forms which our country yields. Here, too, belong the Knapweeds (*Centaurea*), and the Burdocks (*Arctium*). In this section the flowers are all tubular, as in the disk of the *Corymbiferæ*. The flowers are also usually longer, producing a more oblong head, and the involucre-leaves (phyllaries) are more conspicuous in form and colour than in the Daisy group. The Thistles

themselves (*Carduus, Cnicus, Onopordon, Carlina*) are among the most perfect examples to be met with in our flora of defence against grazing animals. The beautifully-cut leaves are fringed with an array of spines of wonderful sharpness; the stems have often wings similarly armed; the leaves of the involucre end each in a spine likewise, sometimes of quite terrifying size, as in the Milk Thistle (*Silybum Marianum*). Were it not for this impenetrable armour the plants would early fall victims to herbivores, for the stems and leaves are juicy and sweet. The most perfectly protected of our native species is perhaps the little Carline Thistle; for the botanist who desires a

Fig. 4.—Carline Thistle (*Carlina vulgaris*). (Half natural size.)

specimen, the only method of securing one with an ungloved hand is to get down under the ring of basal leaves and grasp the strong tap-root. This species is also remarkable among British Thistles for the dry and woody nature of every part of the plant, which preserves its form unchanged if withered, so that one may even find in a sheltered spot a last year's and a this year's plant standing side by side, the former bleached and battered, but unchanged in form of leaf and flower.

Most of our Thistles are biennial herbs, forming in their first year a large rosette of spiny foliage, often of great regularity and beauty, and in their second year, shooting up, flowering, fruiting, and dying. A few species, however, notably the too common Field Thistle (*Cnicus arvensis*), have underground creeping stems. The stems of the Field Thistle plunge so deeply into the soil, grow so rapidly, and are so brittle and tenacious of life, that it is one of the most troublesome of all our weeds. The deeply lobed and spiny leaves of the Thistles are often coarsely hairy, but sometimes smooth and shining; in the Milk Thistle they are variegated by having the veins picked out in pure white. The leaves are often assisted in their function of assimilation by the leaf-like spiny wings which run down the stems, and protect them from injury. Almost all our Thistles furnish beautiful examples of parachute-fruits, each fruit being crowned with a spreading ring of delicate hairs, of which each one again bears a row of smaller hairs down each side Suspended below this delicate framework the seeds are borne to long distances. Passing by the genera *Serratula* and *Saussurea*, each of which has but a single British representative, we come to the Knapweeds (*Centaurea*), which may chiefly claim attention here on account of the interesting variety which they offer in the form of the involucral leaves. Those of the Black Knapweed are familiar to every child whose luck it is to live in the country—curious little dark-brown objects, remarkably resembling certain small animal forms which even naturalists are generally glad to avoid. In other species they are yellow and chaffy. In *C. solstitialis*, St. Barnaby's Thistle, on the contrary, the phyllaries end in long slender spines, while in the Star-Thistle (*C. Calcitrapa*) the spines are much larger, stronger, and spreading, guarding the flower-heads like an array of bayonets. Another interesting point about the Knapweeds is that they show sometimes a differentiation in the structure and function of the flowers, as we have seen in the *Corymbiferæ*. This is best exemplified in the Bluebottle (*C. Cyanus*), which brightens our corn-fields with stars of brilliant blue in autumn. The blue colour is derived entirely from the outer ring of flowers, which consist merely of brilliant corolla, the centre being occupied by numerous small close-set purple perfect flowers, which benefit by the visits of insects which the brilliance of the barren ray-flowers induces The Great Knapweed (*C. Scabiosa*) shows a corresponding division of labour. The Black Knapweed (*C. nigra*) has apparently not yet made up its mind whether to go in for a ray or not. Normally the flower-head consists of a solid disk of fertile flowers, but rayed forms are constantly to be met with.

Lastly we have the Dandelion group, or *Ligulifloræ*, represented by a dozen genera, most of which agree in having yellow heads of flowers closely resembling those of the Dandelion. The character of the group lies in these flower-heads, which are made up entirely of ligulate perfect flowers, in shape like the ray-flowers of the Daisy group. They are likewise distinguished by their milky, often acrid, juice. Only two of the British representatives of the group have flowers which are not yellow. These are the Chicory (*Cichorium Intybus*), whose large light blue flower-heads are such a delightful feature in sandy fields or on dry banks; and the Blue Sow-Thistle (*Mulgedium alpinum*), a handsome alpine plant, attaining a height of several feet, found on lofty mountains in a few localities in Scotland. One other not-yellow member of the *Liguliforæ* finds a place in British Floras, though not a native, namely, the Salsify (*Tragopogon porrifolius*), which has naturalized itself in meadows in many places, being originally grown in gardens for the sake of its fleshy roots, which resemble Asparagus in flavour. This plant has heads of bright purple florets, which, like its near yellow-flowered relative,

the Goat's-beard (*T. pratensis*), close at mid-day. The Goat's-beard being a common plant, this habit has been much commented on by the older writers, and has earned for it the name of "John-go-to-bed-at-noon." Some of the larger members of the Dandelion group vie with the Thistles in elegance of form. This is especially true of the Sow-Thistles; a well-grown specimen of *Sonchus asper*, with its stout hollow columnar stem, beautiful leaves cut and spiny, with spiny lobes clasping the stem in a curious spur-like fashion, and branching inflorescence, forms an object on which the eye of the plant-lover will rest with admiration and with pleasure.

The Hawkweeds (*Hieracium*) form a remarkable and bewildering group of allied forms, in regard to which, as in the *Rubi*, the term "species" is very difficult of application. Between one end of the series and the other—say between the single-headed alpine section and the tall much-branched *H. boreale* and its allies—a much wider gap exists than between the extreme ends of *Rubus fruticosus*, but nevertheless the gap is completely bridged over by intermediate forms, so that classification becomes nigh impossible. The Hawkweeds are mainly plants of mountain rocks; all are herbaceous perennials, with simple leaves and yellow flower-heads.

Our native *Compositæ* are, for so large a group of plants, singularly devoid of properties or uses. Most of them are harmless plants, and the stems or leaves of a good many have formerly been used as food, either boiled or as salads. A good many are of some use as tonics; a few are febrifuge, or vermifuge. The fleshy root-stocks of the Elecampane (*Inula Helenium*) are still sometimes candied; the Fleabane (*Pulicaria dysenterica*) was formerly, as its name implies, used in cases of dysentery. The Stinking Chamomile (*Anthemis Cotula*) is acrid, and its foliage will raise blisters on the skin; while the Strong-scented Lettuce (*Lactuca virosa*) has milky juice that is acrid and narcotic, and has been used as an opiate. The *Compositæ* can claim to supply, in Colt's-foot, Groundsel, and Thistle, some of the most persistent and troublesome weeds that occupy the attention of the British farmer or gardener. By far the most useful of the native species is the Dandelion (*Taraxacum officinale*), whose roots possess diuretic and tonic properties, and are still much in favour in pharmacy.

MICROSCOPY

Conducted by M. I. CROSS.

POND-LIFE COLLECTING FOR THE MICROSCOPE.

By CHARLES F. ROUSSELET, F.R.M.S.

(*Continued from page* 141.)

THE group of attached forms of Pond-life comprise such Infusoria as *Carchesium*, *Epistylis*, *Zoothamnium*, *Stentor*, etc.; Rotifers such as *Melicerta*, *Stephanoceros*, *Floscules*, etc.; Hydra, all Polyzoa and Sponges. In searching for these forms, a quantity of pond weeds, or rootlets, are brought on shore with the cutting hook, and selecting some likely-looking, fairly clean branches, but not the newest growth, one twig after another is placed in the flat bottle in clean water, where it can be examined from both sides with great ease, both with the naked eye and the pocket lens. The tree-like Vorticella colonies: *Epistylis*, *Zoothamnium*, *Carchesium*, the trumpet-shaped *Stentors*, the Crown Rotifer *Stephanoceros*, the tubes of *Melicerta* and *Limnias*, the various Polyzoa, also Hydra and Sponges, and many others, can at once be seen when present, and in this way good branches can be selected and placed in a separate wide-mouthed collecting bottle containing clean pond water. A little experience will soon teach one which branches are likely to prove prolific. As a general rule one may say that old-looking, but still sound and green, branches will be the best. The water Milfoil (*Myriophyllum*) is one of the best of water plants to examine and collect, on account of the ease with which its leaves can subsequently be placed under the microscope. *Anacharis* is more troublesome, but it is occasionally found covered with Pond-life, and is an excellent weed for the aeration of aquaria.

The rootlets of reeds and of trees growing near the edge of the water should be examined for Sponges and Polyzoa, such as *Lophopus*, *Plumatella*, *Fredericella*, etc. In order to obtain some weeds growing near the middle of a pond or lake, a loaded three-pronged hook, attached to a line, may be used: this is swung round, and may be thrown to a distance of 20 to 25 yards, where it sinks, and the weeds that are caught by the hooks are dragged on shore.

By these various means a good collection of pond organisms can readily be made after a little practice. Though the spring and autumn are perhaps the best season for collecting, Pond-life is never absent, even in the winter under the ice.

Having thus filled some bottles with condensed water from various ponds, and placed some promising branches of water plants in another bottle filled with uncondensed and clean pond water, the bag is taken home. It is a great mistake, however, to overstock the bottles with weeds, as the plants in such crowded bottles may begin to decompose, killing most of the animals in a short time.

On reaching home, the first thing to do is to empty the collecting bottle into larger vessels or small aquaria in such a way that the captures may be more critically examined, isolated, and, if found desirable, placed under the microscope.

By far the best and most convenient way of doing this is to transfer the contents of each bottle into a small window aquarium, filling it up with tap water. The weeds and rootlets that have been brought home are put in another window aquarium in clean pond water.

These small window aquaria, with flat and parallel sides 6 to 8 inches long by 5 to 6 inches high and only $1\frac{1}{4}$ inches wide inside, are the best nurseries for the microscope. The difficulty of seeing and capturing small objects in a large or ordinary round aquarium is very great, and the use of the pocket lens almost hopeless, whilst in these flat and narrow aquaria no object is out of reach of the lens, and the whole contents can be looked over without difficulty and in a very short time.

By placing the tank on a what-not at a convenient height before a window, or before a lamp at night, most of the free-swimming Rotifers will collect against the glass nearest to the light, where they can be examined with the greatest ease and picked up with the pipette if desired. A disk of black card-board placed some little distance behind, produces a very good dark ground, against which the smallest visible specks stand out well.

The condensed pond water is, of course, frequently so dirty with floating particles of *débris*, that it is at first hardly possible to see through it; but after standing half-an-hour it will be found that most non-living particles will have fallen to the bottom, and after several hours the water will be quite clear and every living creature will be readily seen.

During the summer months, when Daphnia and Cyclops are abundant, the net frequently collects these in such numbers that they become a nuisance. In order to separate them, when such is the case, I have adopted the plan of passing the water through a small sieve made of material with meshes sufficiently wide to allow the largest Rotifers and Infusoria to go through, whilst keeping back most of the Cyclops and Water-fleas; the latter are then transferred to a separate tank to be examined by themselves.

It is very desirable to examine the collected objects as soon as convenient, the same day if at all possible, and not later than the day after their capture, as many organisms soon die and disappear under the crowded and unnatural conditions in which they are kept in captivity. Rotifers can often, particularly in

cool and cold weather, be kept for a week or fortnight, and some species, such as *Melicerta*, occasionally for months if food-material in the shape of fresh pond-water can be provided. Failing pond-water, water from hay infusions, which mostly contains quantities of bacteria and minute Infusoria, may be added. The various species of Polyzoa and Sponges can also be kept alive a considerable time by feeding them in a similar way, but Hydras require a fare of Water-fleas if they are to thrive.

For keeping microscopic life I have found no difference between large and small aquaria, but the small tanks are the more manageable; the great thing to be attended to is the proper aeration with water plants, of which *Anacharis*, *Fontenalis*, and *Valisneria* are, perhaps, the best, and not to overstock the tank with either animal or vegetable life. The water need not be changed, but a little fresh pond water should be added from time to time. Larger animals, such as small fish, water-beetles and snails must be excluded altogether from small tanks, and Polyzoa and Sponges must be kept therein in very moderate quantity and small colonies only.

In order to ensure success it is essential to maintain a proper balance between the animal and vegetable life, and also to supply fresh food frequently, for microscopical animals no more than the larger beasts can live long without food. To some extent, no doubt, they feed on each other, but in a small aquarium their hunting ground is very limited and the game soon becomes scarce. *Asplanchna* can be seen under the microscope to feed on *Anuraea*, *Brachionus*, *Polyarthra*, *Triarthra*, and other Rotifers when it can catch them, and their shells and remains are frequently found in Asplanchna's stomach.

On the whole, the best plan is to go out and collect a fresh supply from time to time and as often as may be convenient. I may mention that at the middle of January, I had many thousands of Rotifers in a tank which I collected two days before in the Grand Junction Canal, near Westbourne Park Station. The Canal was covered with blocks of ice, and the time spent near the water did not exceed ten minutes, during which I filled a large bottle with water condensed by means of the ring net.

Everyone who has worked at Pond-life will have experienced how awkward it is to examine with a pocket lens and at the same time attempt to pick out a particular animal in order to place it under the microscope. In order to have both hands free for this operation, and to keep the lens fixed to a particular spot, I devised, some years ago, a small aquarium microscope* (Fig 2), which is simply a flat metal arm, jointed in

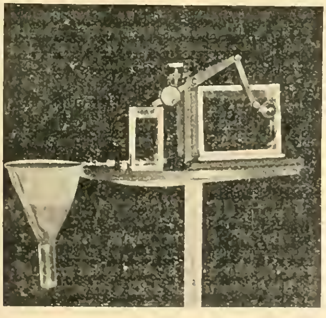


FIG. 2.—Mr. C. F. Rousselet's Tank Microscope and Window Aquarium, with the flat bottle and collecting net.

such a way that it allows the lens to be moved all over the surface, but in one plane only, parallel to the side of the window aquarium, whilst the lens is focussed by a small rack and pinion on the left. The whole apparatus is screwed on to a small wooden stand, on which the tank is placed. The lens used is Zeiss' aplanatic combination × 6 diameters, which has working distance enough to focus right through the tank, and sufficient amplification to enable one to recognise most Rotifers, Infusoria, etc., and anything uncommon or new can at once be detected and secured. Moving objects can readily be followed with the lens, and pond weeds can be searched for anything that may be growing on them, whilst the lens remains fixed in any position it may be placed. I have had this tank microscope in constant use for over twelve years, and can recommend it as thoroughly practical, efficient, and time-saving.

In a future paper I propose to describe those methods which long experience has proved to be the most practical in the examination of living objects under the microscope.

* Made by C. Baker, of High Holborn, and described in *Journal Quekett Micro. Club*, Vol. IV., 1890, pp. 53-54.

THE QUEKETT MICROSCOPICAL CLUB.—It may not be generally known that, in connection with this Club, excursions take place on Saturday afternoons during the summer season to hunting grounds that invariably yield rich spoil to the microscopist. Among the localities yet to be visited this season are Wallington, Totteridge, Chingford, and Hadley Wood. Those who may be interested in Pond-life and similar subjects would derive many advantages from becoming members of this Club, not the least of which is the opportunity of joining these excursions. Communications should be addressed to Mr. A. Earland, Reading Villa, Denmark Street, Watford.

ACCURATE WORKING.—The microscope never does its best except the user apply his best abilities to its manipulation. It is not to be expected that the worker who refers to his microscope as a matter of necessity or routine can give to every point the care that it deserves, and, indeed, properly requires, but it is not too much to expect that those who are engaged in original research, and those amateurs who have leisure and are provided with everything that is the most perfect of its kind, should employ it so as to secure the maximum effect. Those who have seen the wonderful manner in which a Test Diatom or a Rotifer will be displayed by one of our leading workers, will be disposed to credit the objectives used with the greater part of the effect, but it is almost invariably due to the exquisite care which has been bestowed on the arrangements in every small detail. So much of beauty and effect is lost through want of care or lack of appreciation of essentials, that it behoves those who use a microscope to devote to it all the practice and thought that will enable them to wrest from it the best it is capable of yielding. Enough has been written previously of the desirability of proportioning the aperture and power of the substage condenser to that of the objective, and of its use and adjustment, but it is scarcely recognised as it should be how much the critical sharpness and definition can be improved by the use of the mechanical draw-tube.

Neither the complete aperture of the objective nor its fullest correction for spherical aberration are utilised unless this important consideration is studied, and this means, further, that eyepieces of deep power cannot be so advantageously used if it is neglected. Some workers are not possessed of a really keen critical eye, and are not readily able to decide whether an objective works at its best within a variation of tube length of three inches or more, but it is possible to so cultivate this quality as to be sensible of a lessening of effect if the tube length be varied so small an amount as one millimétre, that is, assuming that every other detail has received equal attention. It would be a good manipulative exercise for those who are really interested in seeing all the microscope is capable of revealing, to give careful attention to the minuter details, and especially to the adjustment by tube length.

MOUNTING NOTES.—*Mosses and Liverworts.*—A correspondent has sent some interesting suggestions arising out of the article by Mr. Russell on this subject.

He remarks that "Good glycerine-jelly will not deliquesce in ordinary temperatures; but, like all gelatinous substances, is extremely sensitive to changes of temperature, more especially when accompanied by moisture, expanding and contracting freely. The cement placed round the cover-glass is necessarily rigid, and the cover-glass being usually finally cleaned while held between the thumb and finger, a little grease probably adheres to an occasional edge. Presuming this to be so, when expansion takes place tiny apertures permit the jelly to escape; in fact, when the cement extends some distance over the cover glass capillarity actually invites such escape."

He therefore uses no cements, but after allowing a fortnight for drying, he covers the remainder of the slip with paper, being careful to avoid any pressure when applying it. By this means he has been able to secure mounts which have every promise of permanence, and much trouble in the preparation is obviated.

NOTES AND QUERIES.

W. H. Young.—Mr. J. T. Neeve suggests that you soak the Algæ in methylated spirit for some little time to make them transparent, and, in order that you may experiment, I have sent you some fronds that I have received from him, but is it really necessary for such delicate specimens as *Delisseria* to be treated in this way at all? Are they not sufficiently transparent for lantern projection without this?

E. W. Napper.—The following is the formula for Deane's medium:—

Gelatine	1 oz.
Honey	5 ozs.
Water	5 ozs.
Rectified spirit	½ oz.
Creosote	6 drops.

Soak the gelatine in the water until soft, add the honey, then boil the mixture. When it has cooled somewhat, the creosote mixed with the spirit is added. Lastly, filter through fine flannel. The medium is used warm.

A. H. Brett.—The specimen you send is an egg cluster of whelk.

Communications and enquiries on Microscopical matters are cordially invited, and should be addressed to M. I. CROSS, KNOWLEDGE *Office*, 326, *High Holborn, W.C.*

NOTES ON COMETS AND METEORS.

By W. F. DENNING, F.R.A.S.

FAYE'S COMET.—This interesting periodical comet has probably returned to perihelion this year after a much shorter interval than usual, having experienced considerable perturbation from Jupiter. No information of its recent redetection has, however, come to hand, and the probabilities are that it will escape notice owing to its unfavourable position. This comet has been observed during each of the seven returns which it has made since 1843, and its average period has been 2735 days or 7·488 years. The following is a list of the dates of its perihelia and of its periods of revolution:—

Perihelion Passage.	Period of Revolution. Days.	Date of Discovery.	Discoverer.
1843 October 17	......	1843 Nov. 22	Faye
1851 April 3	2725	1850 Nov. 28	Challis
1858 September 12	2719	1858 Sep. 8	Bruhns
1866 February 13	2711	1865 Aug. 22	Thiele
1873 July 18	2712	1873 Sep 3	Stephan
1881 January 22	2745	1880 Aug 25	Tempel
1888 August 9	2756	1880 Aug. 19	Perrotin
1896 March 19	2779	1895 Sep. 26	Javelle
1903 June 3	2631 (Predicted)		

Dr. Elis Strömgren, of Kiel, gives the following ephemeris in *Ast Nach.*, 3858:—

Date 1903.	R.A. H. M.	Dec. °	Brightness
June 26·5	4 42	+ 18·6	0·055
July 18·5	5 46	+ 18·4	0·053
Aug 9·5	6 45	+ 16·8	0·0 1
„ 31·5	7 39	+ 14·1	0·049

When last seen on 1896, January 15, the light of the comet was = 0·061, so it should be rather fainter than that during the present summer, when it will be not far west of the sun and moving from the head of Taurus, through Gemini, into Cancer.

NEW COMET.—On April 17, Mr. J. Grigg, of Thames, New Zealand, discovered a small comet in the S.E. region of Cetus. It was soon found that the object had passed its perihelion on March 25 and was receding both from the sun and earth. It was observed by Mr John Tebbutt at Windsor, N.S.W., on April 26, but its position since its discovery has been too far south for English observers to obtain a view of it.

APRIL METEORS.—Prof. A. S. Herschel, at Slough, secured a valuable series of observations between April 16 and 23, watching for 21 hrs. 20 mins., in the aggregate, and recording 85 meteors, of which 23 were Lyrids. Meteors were generally very scarce. 8 Lyrids were seen in 2¾ hrs. on April 21, and 11 in 5 hrs. on April 22. The radiant was at 269° + 34°, and about 4 degrees in diameter.

Mr. A. King, of Leicester, watched for meteors on nine nights, from April 15 to 24, the weather being extremely favourable. In 19½ hrs. observation he registered 80 meteors, including 25 Lyrids. The latter were nearly all seen on April 21 and 22, and the maximum occurred on the 21st, but it was rather a feeble display.

Several bright meteors were also seen from a radiant at about 216° − 26°, which represents a return of a well-defined shower observed by Prof. Herschel and others, from the point 218° − 31°, during the April epoch of 1900.

MAY AQUARIDS.—A rich display of these meteors was observed by Mr. G. M. Knight, of London, W.C., on the first four mornings of May last. 25 Aquarids were recorded, of which 18 were equal to or exceeded stars of the 1st mag. in brilliancy. They had long flights, slow motions, were generally of an orange colour, and left fine trails. The mean place of the radiant was at 330° ± 0°, but Mr. Knight thought that the point exhibited a decided N.E. movement during the four nights of observation, the centre, before sunrise on May 1, being at 327° − 3°, while on May 4 it appeared to be at 332° + 3°.

MAY METEORS.—A period of very clear summer-like weather occurred between May 18 and 31, and observations were obtained by the writer, at Bristol, on 11 nights. Meteors were, however, visible in scanty numbers, only 75 being noted in 18¾ hours of watching. There were feeble radiants at 194° + 58°, 248° + 27°, 263° + 37°, 273° + 22°, 278° + 31°, 311° + 80°, 330° + 58°, and 331° + 72°. Perhaps the most interesting object recorded was a small fireball, which appeared on May 26, 13h. 48m., falling very slowly in 4 seconds, from 143° + 71° to 98° + 66½°. A stream of yellow sparks followed in the immediate wake of the nucleus as it sailed leisurely down the northern sky.

DOUBLY-OBSERVED METEOR.—Prof. Herschel, of Slough, recorded a meteor, equal in brightness to Vega, on May 26, 11h. 47m. It traversed a path from 225° + 73½° to 172° + 56° in 1·2 seconds, and left a rather bright, white streak. The same object was observed by the writer at Bristol, moving rather slowly from 315° + 37° to 309° + 61° in 2 seconds, and leaving a bright streak along three-fourths of its track. The meteor was evidently an early Pegasid directed from 321° + 11°. Its luminous flight began at a height of 64 miles over Dunstable, and ended near Burford, Gloucestershire, extending over 51 miles at a velocity of 31 miles per second.

LARGE METEORS.—On May 8th, 5h 30m p.m., Miss Westmacott, at Haslemere, Surrey, observed what appeared like a silver meteor travelling with great speed from E. to W., at an angle of about 35 degrees On Sunday, May 24th, two bright meteors were noticed by the Rev. W. F. A. Ellison, of Enniscorthy. The first appeared at 10h. 20m G.M.T., and was about equal to Venus. It passed slowly from 180° − 8° to 133° + 12¾ in 6 seconds. Colour white or yellowish. It left a long faint train. The second meteor appeared at 10h. 59m. G.M.T., and was of the brightness of Mars. It travelled from 172° + 51° to 267° + 73° in 3 seconds, and left a broad and strong nebulous train. The radiants of these meteors were probably at 252° − 24° and 147° − 12°, but no other observations have come to hand.

THE FACE OF THE SKY FOR JULY.

By W. SHACKLETON, F.R.A.S.

THE SUN.—On the 1st the sun rises at 3.48 and sets at 8.18; on the 31st he rises at 4.22 and sets at 7.50.

The earth is at its greatest distance from the sun on the 3rd, when the sun is in apogee, and then has its least apparent diameter of 31′ 30″·6.

Small groups of sunspots have been frequent of late.

THE MOON:—

	Phases.	H. M.
July 1	☽ First Quarter	9 2 P.M.
„ 9	○ Full Moon	5 43 P.M.
„ 17	☾ Last Quarter	7 24 P.M.
„ 24	● New Moon	12 46 P.M.
„ 31	☽ First Quarter	7 15 A.M.

The moon is in apogee on the 10th, and in perigee on the 24th.

There are two occultations of comparatively bright stars during the month. The particulars are as follow:—

Date.	Star Name.	Magnitude.	Disappearance.			Reappearance.			Moon's Age.
			Mean Time.	Angle from N. Point.	Angle from Vertex.	Mean Time.	Angle from N. Point.	Angle from Vertex.	
			h. m.	°	°	h. m.	°	°	d. h.
July 9	ρ^1 Sagittarii	3·9	8 4 P.M.	65	97	9 11 P.M.	291	317	14 14
„ 19	38 Arietis	5·2	1 50 A.M.	52	92	2 47 A.M.	272	310	23 20

THE PLANETS.—Mercury is a morning star in Gemini, rising about an hour before the sun at the beginning of the month; this interval, however, rapidly diminishes and the planet is in superior conjunction with the sun on the 26th.

Venus is an evening star, and increasing in brilliancy in consequence of her diminishing distance from the earth. She attains her greatest easterly elongation of 45° 30′ on the 10th, when she exhibits the phase of the half moon and has a diameter of 25″. The diameter of the planet rapidly increases from 22″ at the beginning of the month to 32″ at the end, whilst the phase changes to crescent at a correspondingly rapid rate. The period of "greatest brilliancy" does not take place until about one month after greatest elongation. At the middle of the month the planet is on the meridian at 3.7 P.M., having an altitude of $47\frac{1}{2}$°; a little searching with a pair of field-glasses should enable the planet to be found readily. On the 1st of the month Venus sets at 10.30 P.M., and on the 31st at 9 P.M.

Mars is getting more to the west, and also is decreasing in brightness. During the month the diameter decreases from 8″·4 to 7″·2. On the 1st he sets at 11.45 P.M., and on the 31st at 10.10 P.M. The planet is describing a direct or easterly path in Virgo, and on the 22nd passes about $1\frac{1}{2}$° north of Spica. Mars is in quadrature with the sun on the 6th, when he presents the maximum gibbosity, 0·87 of the disc being illuminated. The planet is near the moon on the 1st, and after he has set to the British Isles he approaches at 2 A.M. on the morning of the 2nd within 9′ of the southern limb of the moon.

Jupiter rises on the 1st about 11.20 P.M., and on the 31st at 9.20 P.M., therefore as Venus is setting Jupiter is rising. The planet is describing a direct path in Aquarius up to the 14th, when he is stationary, after which date his motion is retrograde. About the middle of the month the polar diameter of the planet is 41″·4. This year the planet will be a little better placed than last, since he is gradually moving to a higher declination.

Saturn is in opposition on the 30th; he is situated in Capricornus, and rises on the 1st about 9.45 P.M., and on the 31st about 7.45 P.M. The planet, however, is not very favourably situated on account of his south declination of 19°. The polar diameter of the ball is 17″·2, and the outer diameters of major and minor axes of the ring are 42″·9 and 13″·7 respectively. The northern surface of the ring is visible.

Uranus rises about 7 P.M. on the 1st, and about 5 P.M. on the 31st; near the middle of the month he is on the meridian at 10 P.M. As shown by the chart in last month's number, his path lies near 51 Ophiuchi.

Neptune is out of range, being in conjunction with the sun towards the end of last month.

THE STARS.—About 9 P.M. near middle of the month:—

ZENITH . Draco, Hercules, Lyra.
SOUTH . Corona, Serpens, Ophiuchus, Libra, Scorpio.
EAST . Delphinus, Aquila, Capricornus; Sagittarius to the S.E.; Pegasus and Cygnus to the N.E.
WEST . Bootes, Great Bear, Cor Caroli, Leo, Virgo.
NORTH . Ursa Minor, Cassiopeia; Capella on horizon.

Chess Column.

By C. D. LOCOCK, B.A.

Communications for this column should be addressed to C. D. LOCOCK, Netherfield, Camberley, and be posted by the 10th of each month.

Solutions of June Problems (J. C. Candy).

No. 1.

1. R to Bsq, and mates next move.

No. 2.

Key-move—1. R to Kt2.
If 1. . . . P to R3, 2. R to R2.
1. . . . K to K5, 2. R to B2.

SOLUTIONS received from "Alpha," 2, 4; W. Nash, 2, 4; G. A. Forde (Major), 0, 0; "Looker-on," 2, 4; W. H. S. M., 2, 4; G. W. Middleton, 2, 4; "Quidam," 2, 4; J. W. Dixon, 2, 4; C. Johnston, 2, 4; H. F. Culmer, 2, 4; T. Dale, 2, 4; E. A. Servante, 2, 4; A. H. H. (Croydon), 2, 0; W. J. Lawson, 0, 0.

Solution of Conditional Problem (Mrs. Baird).

White's last move was P (Q5) × Kt at K6. He retracts this and plays instead B to Ktsq. Black then plays Kt to QB4, allowing B × B mate.

Correctly solved by J. W. Dixon, C. Johnston, G. A. Forde (Major), W. H. S. M., H. F. Culmer, W. Nash, T. Dale.

G. A. Forde (Major).—Probably I need not point out where you have gone astray. I suspect that your 1. RQB5 was a clerical error.

W. Nash.—15. P to Kt3 was an unfortunate misprint for B to Kt3. So also 18. R to Q2 for B to Q2, as you correctly guess.

P. H. Williams.—Many thanks. They shall appear before the year is out.

Hamilton White.—I must explain that a "cook," in chess parlance, signifies a second solution. To "suspect a cook" means therefore to suspect the possibility of a second solution; not, as you appear to take it, to suspect the *bona fides* of a correspondent.

E. A. Servante.—I expect that your problems will be found up to the standard.

SOLUTION TOURNEY.

The following are the principal scores up to the end of June:—

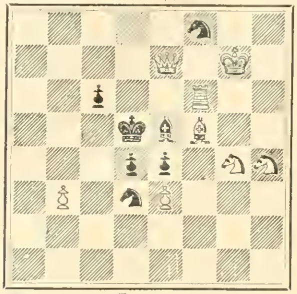
W. Nash	38
Looker-on	38
J. W. Dixon	38
C. Johnston	38
W. H. S. M.	34
G. W. Middleton	34
Alpha	30
A. H. H. (Croydon)	30
Quidam	29

PROBLEMS.

By P. G. L. F.

No. 1.

Black (7).

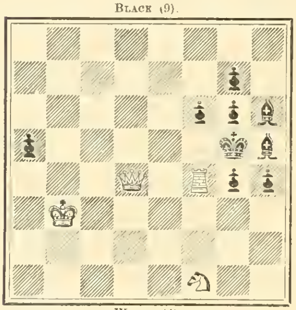


White (8).

White mates in two moves.

No. 2.

Black (9).



White (4).

White mates in three moves.

The very lively game below was played in the Monte Carlo Tourney.

"Centre Counter Gambit."

White. Dr. Tarrasch.	Black. J. Mieses.
1. P to K4	1. P to Q4
2. P × P	2. Q × P
3. Kt to QB3	3. Q to QR4
4. P to Q4	4. Kt to KB3
5. B to Q3	5. B to Kt5
6. KKt to K2	6. P to K3
7. B to KB4 (*a*)	7. Kt to Q4
8. B to Q2	8. Kt × Kt
9. P × Kt	9. Kt to Q2
10. Castles	10. P to QB3
11. Q to Ktsq (*b*)	11. B × Kt
12. B × B	12. Q to B2
13. P to KB4	13. B to Q3
14. B to Q3	14. P to KKt4
15. Q to Bsq	15. Kt to B3
16. P to B4	16. Kt to R4
17. P to Kt3	17. P × P
18. Q to Qsq (*c*)	18. Kt to Kt2
19. P to B5	19. B to K2
20. B × P	20. Q to Q2
21. P to B3	21. P to KR4
22. B to K5	22. K to Bsq
23. B to Kt6	23. P to B4
24. B × RP	24. B to Kt4
25. B to B3	25. R to R3
26. K to Kt2	26. K to B2
27. P to KR4	27. B to K6 (*d*)
28. Q to K2	28. P to B5
29. Q × B (!)	29. Kt to B4
30. Q × P	30. R to KKtsq
31. Q × R (!)	Resigns.

Notes.

(*a*) Apparently wasted time, but the same would apply to Black's reply.

(*b*) To unpin the Knight. By its capture Black gives his opponent the advantage of two Bishops in an open position.

(*c*) Black is now caught in a trap of his own setting. His last five moves have simply been waste of time, and he now loses the Pawn gained, and obtains besides a practically losing position.

(*d*) Apparently overlooking the uselessness of his next move; but in any case the position is quite hopeless. The White Queen does some surprising execution at the end.

CHESS INTELLIGENCE.

The following was the final result of the "King's Gambit" Tourney at Vienna:—M. Tchigorin, 13; F. J. Marshall, 11½; G. Marco, 11; H. N. Pillsbury, 10 G. Maroczy, J. Mieses and R. Teichmann, 9; Sviderski, 8½; C. Schlechter, 7; I. Gunsberg, 2. Mr. Teichmann would have been higher but for ill-health, but Mr. Gunsberg made a very disappointing reappearance.

The Championship of the Southern Counties' Chess Union has been won for the seventh time, by Surrey, for whom Mr. G. E. Wainwright has played at the top board. Worcestershire, led by Mr. Bellingham, have come out at the head of the Midland Counties' Union for the third year in succession.

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CONTENTS.

THE ANCESTRY OF THE ELEPHANT.

By R. Lydekker.

The two existing species of elephants—Asiatic and the African—are not only the largest, but also two of the most isolated among the animals of the present day. For although evidently allied to more typical hoofed mammals, like rhinoceroses, yet they are so different, that their relationship is evidently remote. Elephants are not unfrequently spoken of as "antediluvian" creatures; and if this term be regarded as equivalent to ancient, it is to a great extent a true statement of the case, for elephants and their progenitors, the mastodons, flourished during epochs which are old indeed in relation to human chronology, although modern from a geological standpoint. But "antediluvian" implies in this sense, if we mistake not, more than mere antiquity, and indicates the primitive structural characters of the animals to which it is applied. In certain respects an elephant is indeed decidedly primitive, or generalised, although in other ways it is just as specialised. In the possession of five toes to each foot, as well as in the structure of the wrist and ankle, elephants are indeed truly primitive. Not improbably, in spite of the fact that the opposite view has been suggested, the same is the case with regard to the peculiar conformation of their limbs, which differ from those of all living mammals. That is to say, in place of a marked angulation at the junctions of their different segments, the bones of each limb are placed almost vertically one above the other. This structural peculiarity is, of course, best displayed in the skeleton, although the straightness of limb is very perceptible externally, more especially in the case of the African species. The same feature characterises certain extinct mammals, of the approximate size of rhinoceroses; and from this it might be assumed that straight limbs were common to all the earlier animals. Such, however, is certainly not the case, the primitive carnivora, which come very close to being the ancestral type of all the higher mammals, having the limb-bones as much angulated as in a dog. From this it has been suggested that straightness of limb is a feature of comparatively modern origin, developed for the purpose of carrying the immense weight of an elephant. But, as mentioned later, the same feature apparently occurs in the early ancestors of the elephant, which were much smaller creatures; and if such a type be necessary in the case of an elephant, why is it not equally essential in that of such a huge animal as the white rhinoceros? As regards limb-structure, elephants are therefore apparently primitive.

On the other hand the trunk, or proboscis, of an elephant is a decidedly specialised organ, developed in correlation with the great length of limb and shortness of neck characteristic of elephants and mastodons.

Equally peculiar and specialised is the dentition of elephants, which consists of cheek-teeth, or grinders, and tusks. The latter, which are most fully developed in the males, and are preceded in infancy by a minute baby-pair, are confined to the upper jaw, and correspond to the front teeth of beavers, and not to the tusks of swine. Some of the mastodons had only upper tusks, but in others a pair was also developed in the lower jaw.

Elephants, like tortoises, attain a prodigious age, living to between one hundred and fifty and two hundred years, if not more. To attain this age, it is obvious that they must have teeth calculated to last much longer than those of other mammals, which become worn out within twenty-five years, or much sooner. In nature there are two ways by which teeth may be made to last longer than usual. They may either grow throughout life, like the incisors of the beaver, or their crowns may be abnormally heightened. Further aid in the same direction is afforded by retarding the appearance of the hinder grinders, so that they shall not come into use till those in front are nearly worn out; this being merely an exaggeration of what occurs in ourselves, where the wisdom-teeth do not come into use until well on in mature life.

In modern elephants both plans have been followed; the first in the case of the tusks, and the second in that of the cheek-teeth, or grinders. During life six pairs of grinders are developed in each jaw of an elephant; the first pair of each series being small and almost functionless, while the last is of enormous size, and does not make its appearance till late in life, although the exact date of its coming into use (as in the case of the other teeth) has yet to be ascertained. Each tooth consists of a number of tall, thin, transverse plates, closely packed together, and comprising layers of different hardness, so that when worn the grinding surface displays a series of low ridges, forming an excellent millstone. The number of these plates increases from the first to the last tooth in both species; but they are taller, thinner, and more numerous in the Asiatic elephant and its relative the extinct mammoth, than in their cousin the African elephant. As the teeth in the fore part of the jaws are gradually worn away, their stumps are pushed out by those next behind; the whole series coming

up in the jaws in the arc of a circle. By this arrangement it results that there are never more than two teeth in use at any one time on each side of both jaws; while in old age there is but a single pair of cheek-teeth in each jaw. When these last become so worn down as to be useless, the elephant must die; although it is probable that, in most cases, death takes place before such a completely toothless condition is reached.

It is thus evident that modern elephants, far from being primitive as regards their dentition, are highly specialized creatures. The nearest approach to this remarkable mode of dental succession is presented, among living mammals, by the manati, or sea-cow, in which an almost endless series of cheek-teeth come up one behind another in the jaws as those in front are worn out and discarded. In connection with this resemblance in the mode of succession of the teeth of the manati to the condition obtaining in the elephants, it is important to notice that the ancestral elephants, or rather proboscideans, appear nearly related to the progenitors of the manati. In the early ancestral forms of both groups the cheek-teeth were of a normal type as regards their mode of succession, the whole series being in use at once. Consequently, the peculiar mode of succession occurring respectively in the modern elephants and manatis must have been independently acquired in each. Cases of such parallelism in development are common enough in groups of widely diverse origin, but the occurrence of the phenomenon in groups closely connected is a very remarkable circumstance.

As already mentioned, the component plates of the cheek-teeth of the African elephant are fewer in number

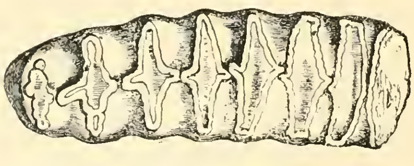


Fig. 1.—Grinding Surface of a Lower Molar of the African Elephant.

and shorter and thicker in form than those of the Asiatic elephant and mammoth. Extinct forms show, however, a complete transition in this respect between the two types. On the other hand, there is a gradation in dental structure from the African elephant towards the extinct group of stegodons, or ridge-toothed elephants, of which the fossilised remains are met with abundantly in late Tertiary formations from India and Central Asia to Japan and Java, but have hitherto been found in no other part of the world. In these ridge-toothed elephants, as their scientific name of stegodon implies, the plates of the cheek-teeth are reduced to low transverse ridges, recalling the pitch of a slate roof. Each ridge is separated from its neighbour by an open V-shaped valley; and the number of ridges in each tooth is much less than in the corresponding tooth of the true elephants. A further peculiarity is to be found in the circumstance that in the third, fourth, and fifth pairs of teeth the number of ridges is nearly the same. This equality in the number of ridges in their "intermediate molars," as they have been designated, forms a connection between the ridge-toothed elephants and the mastodons.

Owing to the millstone-like surfaces formed by their cheek-teeth, modern elephants masticate their food by a backwards-and-forwards motion of their jaws. Obviously, however, such a movement would be incompatible with transverse ridges separated by open valleys on the summits of the cheek-teeth; and it is consequently evident that the ridge-toothed elephants, as well as their predecessors the mastodons, masticated their food partly by a champing and partly by a sideways movement of the jaws. Such a difference in the method of mastication is noticeable between the modern and ancient representatives of several groups of hoofed animals—notably in the case of the horse as compared with its progenitors.

One of the ridge-toothed elephants, as well as another extinct Asiatic species more nearly allied to the African elephant, displays a peculiarity in its dentition which tends to show the derivation of the group from animals of a less specialised type. To explain this it must be mentioned that the whole six pairs of cheek-teeth developed in each jaw of a modern elephant, from childhood to maturity, correspond with the baby-molars *plus* the permanent molars of the human dentition; the only difference as regards number being that the elephant has three of these baby-molars, whereas the human infant possesses but two on each side of both jaws. Consequently, the elephant possesses no representatives of the premolars or bicuspids which vertically replace the baby-molars of the human infant as they become useless. That is to say, except in the case of its tusks, an elephant has no vertical replacement of its teeth; in other words, it has lost the premolars common to other animals.

From the stegodons, or ridge-toothed elephants, it is but a step to the mastodons, which are mainly distinguished by the inferior height and smaller number of their transverse ridges. In the "intermediate" molars of one type of mastodon, the number of ridges is four on each tooth, although, as a rare abnormality, there may be five. Mastodons show a step away from elephants in the fact that there may sometimes be portions of three cheek-teeth in use on the same side of one jaw at the same time; this being due to the smaller size of the teeth.

Here it is important to notice that the species of mastodon which presents the nearest approximation to the stegodons—namely the broad-toothed mastodon—occurs in the same countries as the latter, that is to say in Northern India, Burma, &c. In this species there were tusks only in the upper jaw, and the lower jaw terminated in front in a short spout. As regards both these features,

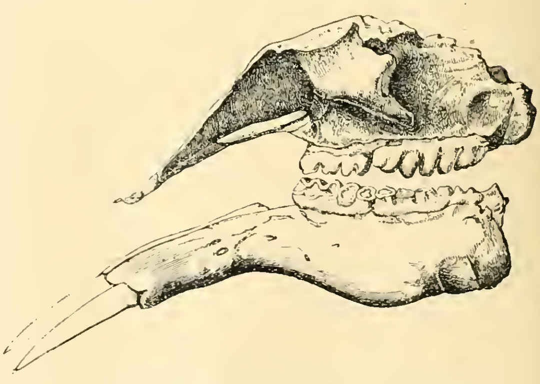


Fig. 2.—Imperfect Skull of a four-ridged Mastodon, showing only two molar teeth (the penultimate and last) in use on each side of both jaws. (From a specimen in the British Museum.)

the North American mastodon, which appears to have survived into the human period, was a very similar

animal, but each of its "intermediate" molars was three-ridged.

A more primitive type is indicated by the four-tusked mastodons, in some of which the "intermediate" cheek-teeth are three-ridged, while in others they are four-ridged. In most or all the members of this group the lower pair of tusks are short, and project from the extremity of a long trough-like extension of the lower jaw. Moreover, in a skeleton of *Mastodon angustidens* now mounted in the Paris Museum, the upper tusks are bent downwards so as to cross and project far below those of the lower jaw. As regards its head, this mastodon, which is one of the oldest of its kind, occurring in the Miocene strata of the Continent, must have been very different looking to an elephant. To correspond with the trough-like elongation of the lower jaw, the upper part of the muzzle was probably prolonged in proportion; and consequently the proboscis was relatively short.

Contemporaneously with the species last mentioned lived another elephant-like creature—the dinotherium—characterised by the presence of a pair of downwardly-bent tusks in the lower jaw, and the more ordinary structure of its cheek-teeth, of which all five pairs were in use at the same time. These teeth recall, indeed, to a considerable extent those of a tapir, the two hinder pairs in each jaw being surmounted with a couple of transverse ridges. The tooth in advance of these has, however, three ridges, like the "intermediate" molars of some mastodons, and the same is the case with the last milk-molar, which in a young animal is situated immediately in advance of the permanent three-ridged tooth. In the adult the three-ridged milk, or baby-tooth, is, however, vertically replaced by a successional tooth of simpler structure, as in ordinary mammals. In build, the dinotherium was probably very like a short-trunked elephant; it may, perhaps, have obtained its food by wading mid-leg deep in lakes and marshes, and thus bringing its mouth within reach of the water-plants.

Although the dinotherium tends to connect mastodons and elephants with ordinary hoofed mammals, so far as its cheek-teeth are concerned, yet the peculiar form of its lower tusks, and the absence of weapons of this nature in the upper jaw, show that it is not the ancestral type of the former. On the contrary, elephants and mastodons on the one hand, and the dinotherium on the other, form branches of a common ancestral stock which till lately was quite unknown. Indeed, the seemingly sudden appearance of the proboscideans, in the form of both these branches, in the Miocene strata of Europe, had long been one of the puzzles of palæontology, and remained so till light was thrown on the subject from an unexpected quarter.

The region whence this light has come is the Fayum district of Egypt, from the Lower Tertiary, or Eocene, deposits of which remains of unknown forms of vertebrates have been recently exhumed. Among these, are jaws and teeth of a small and primitive mastodon, related in many respects to *Mastodon angustidens*, of which it may have been the ancestral form. In this connection it may be mentioned that remains of the latter species have been met with at Moghara, to the north-west of the Fayum.

The lower jaw of this early mastodon resembles that of *M. angustidens* in the elongation of the trough-like anterior portion, and also in the cheek-teeth, which are three-ridged. There is, however, the important difference that the last molar resembles those in front of it in the number of its ridges, in place of having four ridges, and also that the whole five cheek-teeth are in use at once. Nor is this all, for the anterior two of these teeth are premolars, instead of milk-molars; that is to say, they have vertically replaced deciduous predecessors. Clearly, then, this Egyptian Eocene mastodon—palæomastodon, as it is called—is a proboscidean but little removed as regards the characters of its cheek-teeth from ordinary hoofed mammals, although in the production of the lower jaw, and the reduction of the front teeth to a single pair of tusks in each jaw, it resembles typical mastodons. Apparently, the limb-bones conform to the ordinary proboscidean type, from which it may be inferred that the legs were constructed in much the same manner as in an elephant. The fact that such a comparatively small animal has a conformation of limb similar to that supposed to have been developed for the purpose of carrying the enormous weight of an elephant, throws doubt on the theory of the secondary origin of this type of limb-structure to which allusion has been already made.

An earlier formation in the Fayum district has yielded remains of an allied animal—the mœritherium—so named from the ancient Lake Moeris, near the bed of which it was discovered. This creature, which was about the size of a tapir, departs widely from a mastodon, and still more

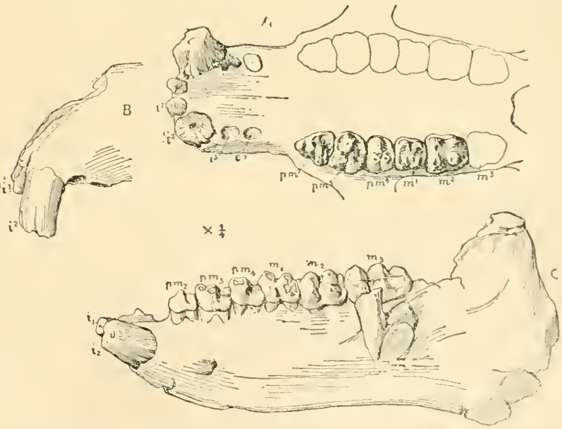


Fig. 3.—The Imperfect Skull (A and B) and Lower Jaw (C) of the forerunner of the Elephants (the Mœritherium). i^1—i^3, incisors; *c*, canine; pm^2—pm^4, premolars; m^1—m^3, molars. (By permission of Dr. C. W. Andrews, the describer and joint-discoverer of the ancestral proboscideans.)

from an elephant. Nevertheless, there are many features in its structure pointing to the conclusion that it is an ancestral member of the proboscidean stock. Each jaw is furnished with six pairs of cheek-teeth, all of which are in use at the same time; the series consisting of three pairs of premolars and as many molars. The latter are not unlike the corresponding teeth of many early-hoofed mammals—some of the extinct pigs, for instance—and, with the exception of the last in the lower jaw (which is three-ridged), carry two transverse ridges. They display, however, a tendency to the development of three ridges, thus foreshadowing the mastodon type.

Very remarkable are the front teeth. In the upper jaw these comprise four pairs, of which the second is much larger than either of the others. The first three pairs correspond to the incisors of a pig; while the fourth pair represent the canines. Obviously the three small pairs of

teeth are in course of elimination, while the large pair represent the tusks of the mastodons, which are thus shown to correspond to the second of the three typical pairs of incisors. In the lower jaw the canines and the third pair of incisors have disappeared; while of the two remaining pairs, the first are small and functionless, but the second are large and project forwards in a manner recalling the lower tusks of the mastodons, of which they are the forerunners.

Although it would be out of place to discuss its proboscidean features here, it may be mentioned that this skull lacks the great elevation characteristic of the elephants, but has the brain-cavity relatively large. In the former respect there is an almost complete gradation from the elephants through the mastodons to the mœritherium. Obviously the latter animal must have been very short-lived in comparison with an elephant; and it is also evident that it was either trunkless or furnished with a rudiment of proboscis.

The limb-bones are not yet fully described, but it is suggested that they resembled those of the extinct American unitatherium in being placed vertically one above another. If this be so, the theory that elephants acquired their straight limbs in order to support their great weight will certainly not hold good.

The discovery of these new forms has shown that elephants and mastodons, in place of forming a group of unknown origin, are the descendants of small, short-lived and trunkless animals, with a type of dentition not very far removed from that characteristic of hoofed mammals in general. And it is further evident that elephants, in place of being primitive, are a very highly specialised type. Moreover, the absence of remains of forerunners of the mastodons from the Tertiary formations of Europe and Asia, affords evidence that the evolution of the mastodons took place in Africa.

MURRAY AND CHRYSTAL ON "SEICHES."

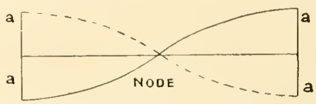
By Dr. J. G. McPherson, F.R.S.E.

The other evening two very interesting papers were read to the Royal Society of Edinburgh on "Seiches," or "standing waves," by Sir John Murray and Prof. Chrystal, the former on the observations and the latter on the theory.

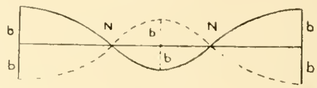
Besides the ordinary forms of waves in fresh-water lakes there are standing waves which have only recently been carefully observed and studied. It is curious to notice that though there is no longitudinal or transverse displacement, there is an oscillatory movement of the whole body of water, so that when at one end of the lake the water is raised by a wave of several inches there is a corresponding depression of the water at the other end.

Forrel, the distinguished authority on waves and their motion, noticed the phenomena in the Lake of Geneva, but he could not accurately account for these. These "seiches," as the standing or undisplaced waves of the entire mass of water are now called, have been recently observed in Como and other Continental lakes; and Prof. Henry has observed a raising of Lake Erie in America to the extent of eight feet, quite independent of the waves caused by strong winds. Sir John Murray and his assistants, Dr. Johnston and Messrs. Murray and Garrett, during last summer, when engaged in bathymetrical observations in Scottish fresh-water lochs, noticed some curious wave phenomena, but their instruments were not sufficiently accurate to produce satisfactory results. However, they have now secured the excellent instrument made in Geneva, which has also been ordered from different stations in Japan and America, and they hope this summer to make more accurate observations, so as to afford Prof. Chrystal sufficient correct data for mathematical investigation.

Mr. E. Maclagan Wedderburn illustrated the different forms of standing waves by an ingenious apparatus; of course the depth of the water in the rectangular trough was far deeper in proportion to the length of the trough than is found in natural lakes; but it brought out to the eye the principles of the motions. In one case the wave of the mass had only one node in the centre, where the bottom of the trough was level. While the water was in motion on both sides of the node, the one part raised, the other part depressed at the same moment, the water at the node was perfectly still. By another arrangement of difference of level in the base, Mr. Wedderburn managed to produce wave motion with two nodes where the water at two points on the surface was still, and the waves were plainly seen in the three remaining portions. By continuing the arrangement he produced several nodes. Thus seiches are uninodal, binodal, and plurinodal, according to the structure of the base of the lakes. They



(*a*) represents a uninodal wave, the dotted part being the complement.



(*b*) represents a binodal wave, the dotted part being the complement.

are rhythmical, and similar to the nodal points of sound-waves. By an ingenious adjustment of the apparatus, Mr. Wedderburn was able to produce a uninodal wave and a plurinodal wave by two sets of motions at the same instant, and a most curious result was produced. Again, by making certain alterations in the base, the nodes were made to occur nearer one end of the trough than the other.

Attacking the general solution by Bessel's formula, Du Boy's period (as guessed by Newton), Kelland's formula, Laplace and Merian's formulæ, Prof. Chrystal has come to some, so far, satisfactory theoretical results; but he is waiting for physical observations of the seiches in the lakes before he goes further, as it would be a mere waste of time so far as any practical and useful results could be obtained.

Prof. Chrystal made some beautiful pendulum experiments to illustrate the oscillatory changes caused by a sort of physical sympathy. From this he concluded that though the surface of Lake Erie is often troubled by seiche motion to a height of eight feet, deep down the water is motionless. The matter is still in its infancy, but this note will indicate the lines on which these observers and calculators are proceeding.

WIRELESS TELEGRAPHY AND WEATHER FORECASTING.

By Arthur H. Bell.

Wireless telegraphy is doubtless destined to play an important part in furthering the advancement of many projects connected with the life of the nation; but it may

be doubted whether any of the enterprises to which it may be harnessed, as it were, will prove so interesting as when it comes to be employed in the business of forecasting the weather. At present the weather prophets are doing the best they can with the ordinary method of sending telegraphic messages, and considering the many obstacles in the way, it must be conceded by any unbiased critic that they do very well indeed. The mere fact, however, that there are so many miles of wire, and so many post offices, between the officials at the central office, where the forecasts are prepared, and their observers who send them the daily reports of the weather, is a serious hindrance to progress, and it will be a happy day for the weather prophets when these intermediaries are abolished.

The general methods by which a modern forecast of the weather is produced have, to many people, an air of mystery, and to the uninitiated few things seem so mysterious and complicated as a weather chart. Most countries nowadays have established offices where such charts are daily compiled, and in all of them the method of procedure is the same. The object aimed at is to obtain a general notion of the state of the weather at a given hour over a large tract of country. To this end a large number of observatories or stations are established in many different localities, it being the duty of the observers to make reports of the weather two or three times a day. The information specially asked for refers more especially to the height of the barometer, to the direction and force of the wind, the state of the sky as regards cloudiness, the temperature of the air, and the amount of rainfall. During a great number of years these observations have been taken in the British Isles three times a day—at 8 a.m., 2 p.m., and 6 p.m.

Now, in order that this information may be of the greatest amount of service, it is important that it should arrive at the head office promptly. The messages accordingly are forwarded by telegraph, so that at the earliest opportunity they may be plotted on to a chart or map. With this weather chart in front of him the official weather forecaster is accordingly informed as to the places where the barometer is rising and where it is falling. On this information he bases his forecasts, and issues, if need be, his warnings as to approaching storms and gales. The reports, moreover, that are telegraphed at other times during the day greatly help as regards giving information concerning the direction in which any storm may be travelling. For instance, the chart may show that a storm has arrived on the west coast of Ireland, and the important thing to know is whether it seems more likely to move north-eastwards across Scotland or south-eastwards across England. It is indeed at such a time as this that the most difficult problems arise, and the mistakes made by the weather prophets are generally due to the fact that the storms suddenly move off in an unexpected direction. Speedy and prompt information from the observing stations is therefore of the highest importance.

Something of the difficulties of the case are understood when the mechanism, so to speak, of one of these revolving storms, cyclones, or depressions, as they are variously called, is examined. Such aerial eddies may be likened to the dimples seen in every running stream of water, for not only have they a rotatory movement, but, like the dimples, they also travel onwards. Cyclones, it should be remarked, vary very greatly in size, and their diameter may be anything from a few yards up to a thousand miles. The smallest of them may be seen at any street corner on a windy day, and, indeed, a little time spent in watching these miniature whirlwinds will give a very fair idea of the causes which produce the larger atmospheric cyclones. Intermediate between the small eddies and the full-grown storms are the whirlwinds and dust storms which career across many of the deserts and arid plains; while in this same category are also to be included the waterspouts that spring up over the sea and some of the larger lakes. All these phenomena are nearly related, and in each there is a rotatory as well as an onward movement. A very fair representation of a revolving cyclone may be obtained by turning a stick very quickly in water, and it will be noticed that the faster the water is made to revolve the deeper does the dent or hollow in the water become. There is a similar relationship between the depth of a cyclone and the velocity of the winds blowing around it. At the centre of every storm the atmospheric pressure is greatly deficient, and the barometer falls to a low level. This pressure increases outwards from the centre of the system, the barometer rising higher and higher towards the outer edge of the storm. Now, when the slope from the outside edge to the centre is very abrupt, like the descent to certain valleys, the barometric gradients are said to be very steep, and it is at such times as these that the wind attains its greatest force. All these, then, are matters that are clearly set forth on a weather chart, and with this information before him the weather forecaster can readily see whether the storm is a severe one, or, in other words, he is able to see whether the atmospheric vortex is very deep.

It is, however, when the attempt is made to forecast the future movements that the difficulties begin, and it is at this point that wireless telegraphy would prove of the greatest assistance to the hapless weather prophets. A few years ago many of the newspapers published storm warnings sent from America, the idea being that storms observed to be setting forth from the American shores would eventually reach the British Isles or some other part of Western Europe. Commonly, the warnings stated that between such and such dates a storm might be expected to show itself on the French, British, or Norwegian coasts, the margin both as regards time and place being large. But many of the storms never arrived, having possibly blown themselves out during their journey across the Atlantic, while others, instead of taking a day or so over the voyage across, would loiter about for days so that the storms failed to put in an appearance or arrived in unexpected places at unexpected times. The experiment of sending the storm-warnings was, however, an interesting one, for it recognised the fact that these cyclones make long journeys without losing their identity, and from this point of view these warnings therefore had their uses.

Contrasted with the weather forecasters in America, the British officials are placed at a great disadvantage, for instead of having a wide continental area to the westward of them, they are bounded by the Atlantic Ocean. All storms, owing to the deflecting movements of the earth as it rotates on its axis, travel from west to east, so that it is the desire of all weather forecasters to obtain early and prompt information from as many places to the westward of them as possible. In this respect it will be seen that a forecaster, say at Washington, is well situated, for to the westward of him he has many observers who send him all the latest information, so that it is much easier to trace the daily progress of a storm as it blusters across the country. But the British forecasters are in much worse case, for they often do not know of the existence of an on-coming storm until it has actually appeared on the west coast of Ireland. The problem, therefore, that has always presented itself has been as to the best means to be adopted for finding out what was happening away out in the Atlantic.

At present the earliest information that can be obtained concerning approaching storms from the Atlantic is received from the observing station at Valencia, in the south-west of Ireland. Now, on more than one occasion, it has been suggested that something might be done in the way of anchoring a vessel or a sort of floating meteorological observatory two or three hundred miles off the coast of Ireland. The opinion has been expressed that there are shoals and shallows that would afford a suitable anchorage; and, indeed, so much enamoured with this scheme were certain enthusiastic meteorologists, that they went so far as to design a floating observatory wherein the observers and the necessary instruments could be housed and floated in mid-ocean. These suggested observatories resembled nothing so much as a gasometer, this being the shape favoured by their designers; and the idea was that the observers would be connected to the shore by a telegraphic wire along which messages could be sent concerning the state of the weather. But in order to carry out this scheme a very large amount of money would be required, and since, moreover, there was apparently no great rush of observers eager to be shut up in the floating observatories, the plan has never been adopted, and it is to be numbered among the things that might have been. It has indeed been suggested that such floating gasometers would with difficulty be kept in position, the chances being that the observers would periodically find themselves bumping about on the coast of Ireland signalling for the steam tug to come and put them in position again.

Another idea that was actually tried was to obtain reports from the steamers arriving at some of the American ports as to the kind of weather they had experienced during their journey across the Atlantic. It was considered that, by thus gaining early information as to any cyclones that might be disporting themselves over the Atlantic, there would be time to telegraph to the weather forecasters in England and warn them that such storms had been encountered. Difficulty, however, was experienced in collecting this information, for, commonly, when a ship arrives in port, the first business of a captain is to see to the landing of his passengers and the discharge of his cargo, there being, as a rule, little time to spare for writing out and dispatching weather reports. Excellent, therefore, as this scheme for gathering information appeared to be, there were difficulties in the way of its full development, and it cannot be said that it proved of any great advantage.

But it is from these swiftly-moving steamers that, perhaps, after all, the weather prophets may, in the near future, derive the much-desired information concerning the weather over the Atlantic. By means of wireless telegraphy, ships are now sending messages to lighthouses, and are in touch with reporting stations scores of miles away. Moreover, it seems clear that ere long messages will be sent over hundreds of miles of space, and when this becomes an every-day occurrence, the weather forecasters will get their chance. Steamers, for instance, leaving Queenstown and Liverpool, may be kept in touch throughout the greater part, and it may even be during their entire journey across the Atlantic. In the messages that would pass from the ship to the British shores there might easily be included information concerning any storms that were encountered on the way. These particulars would refer especially to the intensity of the storm, and the date and place where it was met with. Doubtless, before very long, all the great steamers will be fitted with the wireless telegraphy apparatus, and it will be seen that when the system is in full working order the problem as regards receiving intimation of the approach of storms from the westward will be solved.

Moreover, the further development of wireless telegraphy may not only be expected to prove of use as regards collecting weather information from the Atlantic, but on shore also it will prove of incalculable advantage to the weather prophets. As already mentioned, there is often delay in sending the daily observations of the weather along the ordinary telegraph wires, the arrangements at many of the local post offices often hampering the prompt despatch of important reports. Telegraph offices, in many places, are open only at certain definite hours, and no matter how important may be the message an observer may have to forward to the head office, it can only pass along the wires at certain hours, a circumstance that often greatly handicaps the officials responsible for preparing the weather forecasts.

But not only does this apply to the receipt of the messages, but it applies also to the issue of the storm warnings. When the officials at the central weather office have come to the conclusion that a storm is about to burst over the country, it is, of course, part of their work to send out storm warnings to the seaports, where, as soon as the warning is received, the storm signals are hoisted. Now these warnings have also to be sent by telegraph, and it will be understood that at many of the country and outlying post offices the messages can only be received and delivered up to a certain hour. Supposing, therefore, the weather forecasters were to sit up all night observing the weather, there would, with present arrangements, be no advantage in doing so, because so long as the warnings have to be sent along a wire it is impossible now to get any messages through to those whom they may concern. But here, again, it will be seen that if the wires and the post offices were done away, and communication between the observers and the central office and between the central office and the various seaports were established by means of wireless telegraphy, an added usefulness would be given to the storm warnings and the weather forecasts.

At times, too, it happens that during stormy weather the present telegraphic system breaks down entirely, it being no uncommon thing during a severe snow-storm for telegraphic communication between different parts of the country to be interrupted during many days together. In such circumstances as these, not only is it impossible for the observers to forward their weather reports to the head office, but it is equally impossible for any storm warnings and weather forecasts to be dispatched along the telegraph wires. These are doubtless irritating circumstances that the weather forecaster of the future will know nothing about, for with wireless telegraphy at his service his messages will come and go, no matter if storms may be raging and the whole country buried deep in snow.

There is, therefore, from the weather prophet's point of view, much to hope for from wireless telegraphy, and on the day that the first storm warning is issued by this means, an important epoch in the history of the weather will begin. At present many storms arrive unheralded, but with this new agent at his service, the weather forecaster will keep in touch with them throughout their whole course, and they will be kept under observation from New York, it may be, and right across the Atlantic Ocean to the coast of Norway. Recognising, therefore, the many advantages they will gain from its future developments, it will readily be imagined that those whose business it is to forecast the weather await with interest the improvements that will assuredly continue to be made in wireless telegraphy.

THE DARK HEMISPHERE OF VENUS.

By B. W. Lane.

Although the object of this paper is to add one more theory to the many which have been formed to account for the visibility of this part of the planet Venus, I think I may be excused if I first run over some of the principal theories which have been previously put forward.

The phenomenon itself may be described as follows:— Now and then the part of the planet not lit by sunlight has been observed to shine with a faint light, exactly similar to that emitted by the night side of the crescent moon. This illumination, however, unlike that on our satellite, which is constant, is intermittent, sometimes not appearing for months together, or even longer, even in the best telescopes, and at other times being apparent at the first glance, and on rare occasions being bright enough to have been once or twice visible in the daytime.

There is no satellite to illumine Venus in this manner; the earth is thousands of times too faint at that distance to produce it; the fact that the faintly-lit side always appears smaller in radius than the bright portion, precludes the possibility of its being an optical delusion due to the prolongation in the eye itself of the horns of the crescent. It is therefore, apparently, as Webb calls it, an "inexplicable phenomenon."

All theories having for their basis the suppositional existence of intelligent inhabitants on Venus may, I think, be left over until every other method has been found to fail.

The two theories which are at present most generally considered to be most likely, explain the appearance: the first by supposing auroræ of great brilliancy on the planet, and the second by supposing the atmosphere of Venus to be capable of refracting the sunlight sufficiently to suffuse all the dark side of the planet with a perpetual twilight.

In answer to the first of these theories it may be said that in the first place we can scarcely fairly suppose auroræ of sufficient brightness on Venus, as Mr. Proctor points out, and secondly, auroræ are usually found to occur on such occasions as when a sunspot crosses the solar meridian, and, therefore, if this were the explanation, illuminations should take place when the sun is spotted, rather than at other times, yet no such coincidence has been observed.

Against the second, the objection may be urged that if the dark side is lit up by refracted sunlight at one time it should also be so lit up at another, and even supposing such enormous changes of atmospheric conditions as are necessary to account for the occasional nature of the phenomenon, the terminator is just as sharp and exactly defined on days when the dark side is visible as when the dark side is invisible, whereas if the above were the true explanation, at these times the light and dark sides should fade almost imperceptibly into each other.

The theory which I here intend to put forward attributes the appearance to a factor in the lighting of the sky which has hitherto escaped recognition. I refer to meteor swarms.

Now it seems to me that the brilliant illuminations of the sky caused by the Leonids in the old days before they lost their way, should have been almost if not quite sufficient to make the night side of earth very faintly visible from, say, Mars. Personally I never had the good fortune to see the Leonids in 1866, and still less so in 1833, but when I hear on the authority of Humboldt and others that the swarm was sometimes so thick that at times there were as many meteors visible at once as ordinary stars, and when I compare this with the meteor which I can see any night after ten minutes' watching, it seems to me that the light given out, even after every discount has been taken off for very natural exaggeration, must have been very considerable. When I further read that at some places in 1833 people were wakened up, although the blinds were down, by the flickering light thrown by these meteors, I begin to think that this light must have been not only far stronger than moonlight, but quite enough to make the dark side of our planet visible to other members of our system. Persons who have seen the Leonids thirty-five years ago will, of course, be able to correct any mistaken impression I may have received, out of their own experience.

I think, however, it will be admitted that as there are probably, nay, certainly, larger meteor swarms than the Leonids wandering through space, swarms exceeding the Leonids in density probably as much as the Leonids exceed the ordinary swarms, it is practically certain that these swarms if they collided with a planet having an atmosphere such as Venus undoubtedly has, would be able to light it up quite sufficiently to render it easily, if not strikingly, visible.

The question, then, is, are we justified in supposing that Venus is lit in the same way and by the same means as the earthly night skies have from time to time been illuminated?

The average brightness of meteors entering the atmosphere of Venus will, by reason of their greater average velocity, be about a-third greater than that of meteors entering the earth's atmosphere. Therefore a swarm like the Leonids acting on Venus—other conditions such as inclination of orbit, etc., being equal—would produce about four-thirds the illumination which it produces here. I think, therefore, there need be little doubt that there are meteor streams known to us capable of producing this illumination, or something like it.

The matter, however, does not rest here. The question now is, how often do we meet such streams, and, above all, how often do we meet streams which could produce sufficient illumination to render the dark hemisphere visible in the daytime? Now if we write down six as the number of showers which appear in a century on this earth, and which are at all competent to render a planet visible at any time, we shall be considerably over the mark. We cannot, I think, expect that the number of swarms will, in the ordinary way, be more than twice as great per given unit of space, in the neighbourhood of Venus as near the earth. Putting the figure, however, far higher in our favour than we are really justified in doing, we find that perhaps twenty times in a century Venus may be sufficiently lit up by meteors to become visible. On quite two-thirds of these occasions Venus will be either so near the sun, or in so broad a gibbous phase, as to make the seeing of the dark side an impossibility. We are thus reduced to the possibility that perhaps six times in a century the dark side may be observable. But we are expecting a great deal more than we have a right to do if we suppose that out of these six times it will be observed more than three, whereas the actual number of times that the dark side has been seen is more like thirty, if not far greater.

We thus see that it is utterly impossible for meteor streams of the same order as those with which we are acquainted to produce an illumination anywhere near so frequently as is actually observed.

There is, however, an appearance sometimes seen in the evening sky, and going under the name of the Zodiacal Light. Now whether this appearance is due to a vast

flat disc of gas or to one of meteors, no one can deny that in its course round the sun, Venus passes through a very dense portion of its substance. If now we suppose this appearance to be composed of meteoric swarms, pursuing their way among each other in all directions, their orbits having a general coincidence with the plane of the ecliptic, a view which is gaining ground every day, we at once see how it is readily possible for meteor showers like our November displays to be comparatively common on Venus. On looking at the density of the Zodiacal Light at an angular distance of 40° from the sun, it seems to me as if it would be a wonder, the appearance being meteoric, if Venus were *not* illuminated at times in traversing these swarms. My own opinion is that if the night side of Venus never was illuminated, it would almost be prejudicial to the hypothesis of the meteoric nature of the Zodiacal Light, and in the same way the fact that this illumination can be explained on this hypothesis and on no other, appears to me a strong supplementary indication that this hypothesis is the correct one.

The above theory explains of course the intermittent nature of the light, and although meteoric swarms can only act on one side of a planet, yet in the nature of things, as a little consideration will show, it will only be when a swarm strikes a favourable half of the planet that the light will be seen. Also the movements of the planet are such as to cause the side thus illuminated to be the one most readily noticed by the observer when the planet is in the most favourable position for observation.

One question there is which cannot yet be decided, viz., Do these illuminations ever take place at the same point on the planet's orbit as previous illuminations? If it can be proved that they do, I think the matter might almost be regarded as permanently settled.

THE CHEMISTRY OF THE STARS.

IV.—STARS OF THE FIRST TYPE.

By A. FOWLER, F.R.A.S.

ALTHOUGH Secchi seems to have clearly recognised that the white stars of the "Orion" type were spectroscopically different from those resembling Sirius, he was satisfied to group together all the white stars under the general name of Type I. It has already been pointed out, however, that Secchi's classification is greatly improved by restricting the definition of Type I. so as to include only those stars in which the fine lines accompanying the stronger ones of hydrogen are chiefly of metallic origin, and giving the name of Type O to those stars in which the chief lines, apart from those of hydrogen, are principally due to helium and other gases.

Taking the first type stars in this restricted sense, Sirius may be regarded as the most typical example. Here the dark lines of hydrogen are overwhelming, but the additional lines seen in the best of modern photographs are very numerous and sharply defined, and by no means to be despised on account of feeble intensity. Their chemical significance has lately been very fully investigated by Sir Norman Lockyer, and the following short extract from his recent publication, to which reference has been previously made, will indicate the present state of our knowledge in this direction. It is necessary to explain that in this table the prefix "p" indicates that the line is an "enhanced" one, or one that is stronger in the spark than in the arc spectrum under ordinary conditions of experiment, "p" being an abbreviation for "proto"; the idea underlying the use of this term is that the enhanced lines appear under some condition of molecular simplification.

Lines in Spectrum of Sirius.		Chemical Origin.			
		Probable.		Possible.	
Wave Length.	Intensity. Max. 10.	Origin.	λ.	Origin.	λ.
4000 0	1	—	—	p. Mn	4000·20
4002·7	2	p. Fe	4002·77		
4005·5	3—4	Fe	4005·41		
4012·5	2—3	p. Ti	4012·54	p. Cr	4012·63
4015 7	1—2	p. Ni	4015·76		
4024·6	1—2				
4028·5	1	p. Ti	4028·50		
4030·9	1	Mn	4030 88		
4033·2	1—2	Mn	4033·22	Ga	4033·13
4034·6	< 1	Mn	4034·64		
4035·8	2	—	—	Mn p. V	4035 80 4035 80
4046·0	3—4	Fe	4045·98		
4048·9	2	p. Fe	4049·00		
4052·3	1—2	p. Cr	4052·10		
4053·9	1—2	p. V p. Ti	4053 80 4053·98		
4057·6	1	p. Fe	4057·60		
4063·8	3	Fe	4063 76		
4067·2	3	p. Ni	4067·30		
4071·9	2—3	Fe	4071·9t		
4075·6	1				
4077·9	3—4	p. Sr	4077·88		
4101·8	10	Hδ	4101·85		

From the complete table it appears that the following elements are responsible for the Sirian lines which have so far been identified:—

Aluminium.	Iron.	Silicium.
Barium.	Magnesium.	Strontium.
Calcium.	Manganese.	Titanium.
Chromium.	Nickel.	Vanadium.
Copper (?).	Scandium.	Yttrium (?).
Hydrogen.		

The significant outcome of the investigation is that the chemical origins of the majority of the Sirian lines have already been traced to terrestrial substances, and it is certainly too early to invoke non-terrestrial matter in order to explain the remainder. There is, in fact, no certain evidence of the presence of any substance in the Sirian stars that has not already been found in the sun and upon the earth.

This notable success in the interpretation of the Sirian lines, as will be seen from the wave-length table above given, is largely due to the comparatively recent investigations of enhanced lines; but while the chemical significance of such lines is beyond dispute, their physical meaning is not yet generally agreed upon. Sir Norman Lockyer, Dr. Scheiner, and others argue that they are the products of high temperature; Sir William Huggins seems inclined to account for them chiefly as an effect of reduced density, and others incline to attribute them, in laboratory experiments at least, to a particular electrical condition. Special attention has lately been given to the experimental study of the enhanced line of magnesium at λ 4481 (*see* KNOWLEDGE, February, 1903, p. 32, Fig. 4), which is very prominent in the Sirian stars. It has been shown that this line may be made to appear in the *arc* spectrum if the poles be surrounded by hydrogen or certain other gases, or when the arc is passed under water; while, on the other hand, it almost disappears from the spark spectrum when sufficient self-induction is introduced into the secondary circuit. Similar complex behaviour has also been recorded in the case of other

enhanced lines, but the view that they are generally associated with high temperature at least seems to have as much in its favour as any other which has been put forward.

It has long been recognised that the Sirian type of spectrum is closely related to the solar type, this connection being very clearly shown when intermediate types are studied. Such a connecting link is afforded by stars like Procyon, in which the giant hydrogen lines of the Sirian type are considerably toned down, while the metallic lines, notably those of calcium and iron, are correspondingly intensified. The perfect sequence from the Sirian, through the Procyonian to the Arcturian type, is clearly shown by the three spectra in Fig. 9.

Such photographic comparisons at once suggest that some variation in the condition of a Sirian star, without change of the materials involved, might modify the spectrum so that it became of the Procyonian type, while a further change in the same direction might well produce the Arcturian type of spectrum. The idea of a stellar evolution is, in fact, here presented in its greatest simplicity, the substances actually represented in the three spectra being identical so far as they go.

There are good grounds for concluding that this change of spectrum from type to type is brought about by change of temperature. Apart from the indications afforded by the relative intensities of the proto-metallic and metallic lines, this conclusion is suggested by the difference in the strength of the violet and ultra-violet radiations in the three types of spectra. Experiments teach that as the temperature of an incandescent body, such as a platinum wire, is increased, the violet and ultra-violet rays are added in greater proportion than those less refrangible. Hence the greater intensity of the violet and ultra-violet radiations of Sirius as compared with Procyon, and of Procyon as compared with Arcturus, points to a reduction of temperature in the passage from the Sirian to the Arcturian type in the evolutionary process.

The consideration of the temperatures of stars, as indicated by the relative strengths of their violet and ultra-violet radiations, leads to another very important result, one which seems to indicate that the evolutionary processes are, perhaps, not quite so simple as might appear from the example already given. Sir Norman Lockyer finds that stars of about the same temperature may usually be divided into two groups, in one of which the hydrogen lines are much less strong than in the other, while the additional lines are of greater intensity. He concludes that the first series of stars are still increasing in temperature while the others are decreasing. Thus, Polaris and α Cygni nearly correspond in temperature with Procyon and Sirius respectively, and on this supposition stars of the first and second types may be arranged as follows:—

		Increasing Temperature.	Decreasing Temperature.
Proto-Metallic Stars	Type I.	Cygnian	Sirian
	Type I.-II.	Polarian	Procyonian
Metallic Stars ..	Type II.	Aldebarian	Arcturian

On this view an Aldebarian star passes through the Polarian and Cygnian stages to a maximum of temperature represented by one of the groups of Orion stars, and then, with decreasing temperature, through stages represented in succession by the Sirian, Procyonian, and Arcturian types.

If the evolutionary idea be accepted, it follows that the chemical constituents of the Polarian, Cygnian, Sirian and Procyonian stars are identical with those of the Arcturian, and therefore with those of the sun. The argument for the distribution of solar and terrestrial matter throughout the universe, therefore, becomes stronger the more the spectra of the stars are investigated.

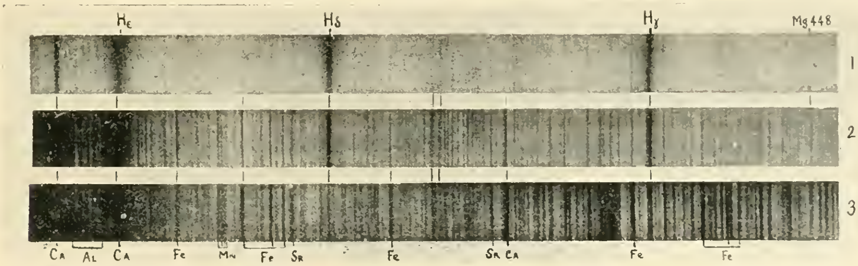


Fig. 9.—Photographic Spectra of β Arietis (1), Procyon (2), and Arcturus (3).

Some of the principal stars of Type I. and I.-II. are as follow:—

Type I.		Type I.-II.	
Cygnian.	Sirian.	Polarian.	Procyonian.
η Leonis	α Aquilæ	η Aquilæ	δ Aquilæ
α Cygni	β Arietis	ε Aurigæ	α Argûs
	β Aurigæ	δ Cephei	γ Boötis
	α Canis Maj.	γ Cygni	α Canis Min.
	δ Cassiopeiæ	β Draconis	β Cassiopeiæ
	α Cephei	ζ Geminorum	α Circini
	β Eridani	α Leporis	γ Herculis
	α Geminorum	α Persei	α Hydri
	β Leonis	α Ursæ Min.	γ Serpentis
	α Libræ		γ Tauri
	α Lyræ		ε Tauri
	α Ophiuchi		β Tri. Aust.
	α Piscium		θ Ursæ Maj.
	α Pisi. Aust.		
	β Ursæ Maj.		
	δ Ursæ Maj.		
	ε Ursæ Maj.		
	ζ Ursæ Maj.		
	γ Virginis		

JUPITER AND HIS MARKINGS.

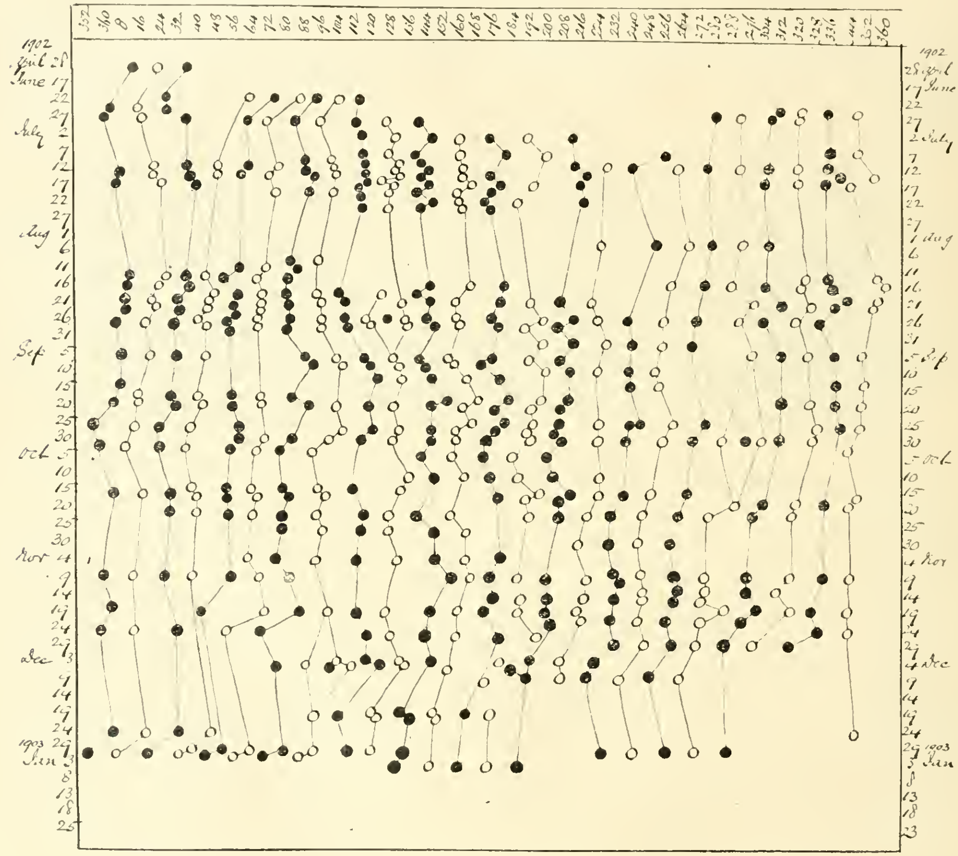
By W. F. Denning, F.R.A.S.

The surface phenomena of Jupiter show no present indication of declining in interest. Nor is it likely that the study

of this gigantic orb will ever be exhausted; the variations in his markings, both as regards their aspect and velocity, are so diversified and the objects so abundant that they offer a comparatively boundless field for investigation. There is indeed every reason to suppose that the ensuing few years will witness increased enthusiasm among Jovian students in the northern hemisphere, to whom the planet will attain a much greater altitude, and appear under a better defined aspect than during the past few oppositions.

As now displayed in the morning sky, Jupiter exhibits many prominent and curious markings. It is true that no distinctly sensational feature happens to be visible, such as the slant-belt of 1860, the great red spot in its striking tint and bold outline of 1878-80, or the rapidly-moving north-temperate spots of 1880 and 1891. But there are a large number of objects perceptible which it is desirable to watch as closely as possible during the remaining part of the opposition. Observers who have micrometers would do well to determine the latitudes of the principal belts and spots every year. Perhaps, however, the main object in surveying this planet is to obtain as many accurate estimates as possible of the times when the various spots pass the central meridian, as these materials enable the individual rates of velocity to be ascertained. The belts and zones of Jupiter may be likened to a series of parallel rivers running along at different speeds, and the irregular spots floating in them afford just the clues required to enable us to ascertain the relative strength of the currents. The study of Jovian detail is essentially directed to questions of motion rather than of aspect, and in its aims and issues is very dissimilar to telescopic enquiries concerning Mars, which have special reference to the forms and positions of the lineaments. This is due to the fact that the spots on Mars are actual surface formations, one and all influenced by an invariable rotation period of 24h. 37m. 22·62s. But telescopic observers of Jupiter are merely studying the outside meteorology of the planet, since his vaporous envelopes preclude any closer acquaintance with the phenomena of his real globe.

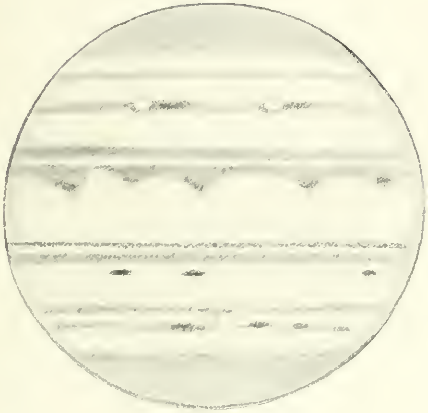
Longitudes of the Equatorial Spots (White ○, Dark ●) on Jupiter, 1902.



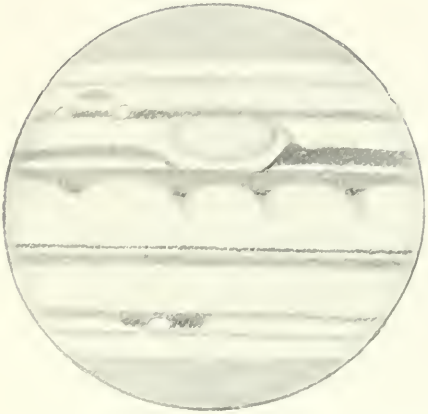
Observations with a 10-inch Reflector, power 312, by W. F. Denning, Bristol.

We may never be able to penetrate this obstructive veil

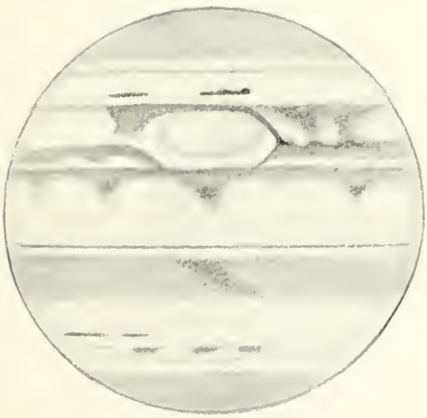
JUPITER AND HIS MARKINGS.



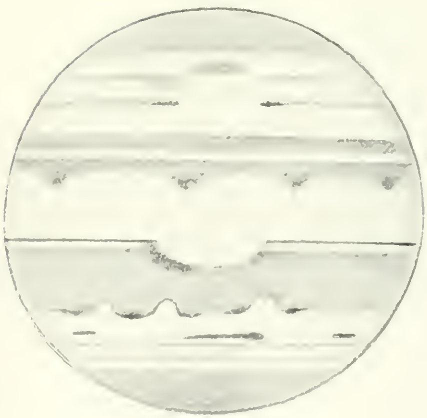
1903, June 20, 15h. 10m.



1903, June 24, 15h. 15m.



1902, July 7, 14h.



1902, July 13, 14h.

Taken with a 10 inch Reflector, power 312, by W. F. DENNING, F.R.A.S.

and gain a clear insight as to the topography of the disc; but what we discern amid the envelopes may afford an intimation of what is progressing below. There seems little doubt that frequent eruptions of material occur from the planet, and that the belts are often reinforced or intensified by this ejecta. A much heated condition of Jupiter seems a necessary inference, and there is observational proof that his giant sphere is in a state of considerable activity. By volcanic agency large volumes of material are probably discharged outwards, and these upon entering cooler regions may be partly solidified, and enabled to float on the heavier lower vapours. The red spot has endured so long, and retained such a permanency of shape, that it must be regarded as a very compact, stable object, possibly developed from some special outburst on the planet's surface at a rather remote period in the past.

More than once, remarkable outbreaks of dark spots have been observed, and these spreading out in a longitudinal direction have ultimately been drifted into new belts by the action of the very swift rotational velocity. But as all or nearly all the markings are influenced by proper motions, it is scarcely possible to ascertain the exact rotation period. There was an outburst of dark material from the planet in 1860 which seems to give us a good clue. It was spun into a new belt on the planet in a period of 64 days, but one end of the disturbance, probably representing the seat of energy, maintained a constant rate of 9h. 56m. 1s., while the other end showed an increasing velocity. If, therefore, we are justified in assuming that the dark material represented an uprush from the planet's surface, the value alluded to must closely approximate to, if it does not coincide with, the rotation period of the Jovian sphere.

In recent years spots may be said to have chiefly abounded in four latitudes, and to have given evidence of marked differences in rate:—

Latitude.	Mean Rotation Period. h. m. s.	Notes.
+ 25° to 30°	9 55 55·3	16 determinations.
+ 10° to 15°	9 55 31·2	35 determinations.
Equatorial Region ...	9 50 25·6	5 years, 1898-1902.
− 25° to 30°	9 55 18·7	29 determinations.
Red spot and hollow in belt. Section of − 20°	9 55 36·56	70 years' observations, 1831-1901. 61,813 rotations.

And these particular regions of the planet are at the present moment very rich in spots of various character. The sedulous study of these currents, and of the objects carried along in them, must be carefully pursued from year to year, for they may ultimately teach us something as to periodical changes of velocity possibly affecting them, as well as enable us to recognise recurrent markings.

In the spring of 1901 several dark projections were observed from the S. side of the S. equatorial belt. These intensified, and a considerable amount of dark matter was thereafter distributed over the S. tropical zone. This enveloped the red spot in July, 1902, and passed that object by flowing round its southern borders. The large tropical spot is still visible, though much fainter than formerly. On June 30 it extended over 47 degrees of longitude, and its centre was in transit at 15h. 34m. Comparing this observation with the position of the same marking at the middle of June, 1901, it will be found that it performed 1795 rotations in the interval, with a mean period of 9h. 55m. 18·6s.

But, of course, the most interesting object on Jupiter is the great red spot. This marking exhibited for many years a retardation in motion which increased its rotation period from 9h. 55m. 33·4s. in 1877, to 9h. 55m. 41·0s. in 1894. Since the latter year the mean values have been as follow:—

	H. M. S.		H. M. S.
1895 ...	9 55 41·1	1899 ...	9 55 41·7
1896 ...	9 55 41·3	1900 ...	9 55 41·7
1897 ...	9 55 41·5	1901 ...	9 55 40·6
1898 ...	9 55 41·6	1902 ...	9 55 39·0

The spot now follows the zero meridian of Mr. Crommelin's System II. by 52 minutes = 31°·4 of longitude. The observations obtained at Bristol since Jupiter became a morning star are as under:—

1903.	Transit Time. H. M	Longitude. °
May 26 ...	16 18 ...	29·5
„ 31 ...	15 28 ...	30·4
June 5 ...	*14 33 ...	28·3
„ 24 ...	15 20 ...	31·6
„ 29 ...	14 29 ...	32·3
July 1 ...	16 7 ...	32·1
„ 13 ...	16 2 ...	32·8

The earlier observations seem to place the spot too far W., but at the time they were made the planet was small and altitude low, and results obtained under such circumstances are rarely so good as those secured nearer the date of opposition. Quite possibly the motion is again retarded.

The chart of equatorial spots visible in 1902 shows their various longitudes during the last six months of the year. The mean rotation period of 24 white and dark spots was 9h. 50m. 26·7s. The irregularities observable in the projected longitudes suggest that these markings have a curious oscillatory motion, and such is indeed the case, though certainly not to the extent apparent in the drawing. Errors in the observed transit times must be partly responsible for a number of the displacements, and considerable changes occur in the dimensions and visible aspect of the spots which must naturally influence the results. But apart from these disturbing causes, the markings have undoubtedly a to-and-fro movement in longitude which sufficiently proves that the equatorial current is subject to decided sectional fluctuations.

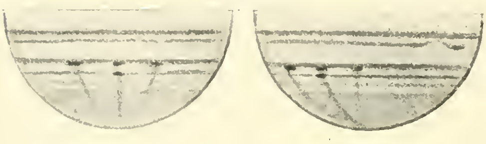
A discussion has recently taken place in *Popular Astronomy* as to the relative value of transits of spots obtained by micrometric measurement and by simple eye estimation. There is really a very trifling difference in the accuracy of the two methods. The micrometer seems capable of furnishing results a little more exact than those depending solely on the eye, but the difference is so small that it may be practically disregarded. Eye-estimated transits are often very precise, for the rapid rotation of Jupiter palpably displaces objects near the central meridian in two or three minutes. Two, or even three minutes of error in the transit time of a spot possess little significance, since the rotation periods are often derived for intervals embracing more than three hundred rotations, and the error will only amount to the small fraction of a second. Even the spots themselves vary in their periods to the extent of ten or twenty seconds or more! What is of far greater importance in studying the markings is to make a large number of observations so as to be *practically certain of their individual identifications*, and to follow them over as long a period as possible, so that the observational errors may be minified, if not eliminated, by their division among a large number of rotations. The misidentification of markings, and the shortness of the period over which they have been observed, have furnished fruitful sources of error.

As to the surface currents, whatever may be said in opposition to the plan of sorting them into zones or parallels of latitude, and ascribing mean rates of motion

* Estimate doubtful, the spot being some distance west of the meridian.

for each one, the plan is necessary, and naturally suggests itself as likely to facilitate the easy retention of our knowledge of detail. The method is certainly not perfect in its application to all the facts accumulated. For instance, spots have temporarily appeared in the north-temperate region with a rotation of only 9h. 48m., yet the normal rate of this latitude is 9h. 55m. 55s., and represents the slowest current of all. But the rapidly-moving spots alluded to formed a very exceptional incident, and should not be allowed to negative a system which has much to recommend it.

Occasionally there are seen markings on Jupiter of a very curious and special description, and apparently dissimilar to all the rest. These are in the form of faint dusky streaks, running from spots on the north-temperate belts to the region of the north pole. They cross the belts at right angles, and one of these features—the centre of three—was very conspicuous on July 1, 1903, in longitude 13°, and in transit at approximately the same time as the preceding end of the great red spot. The aspect of these northern latitudinal spots was somewhat as under :—



15h. 36m. 16h. 12m.

Northern Hemisphere of Jupiter, July 1.

10-in. Reflector, power 312.

They are not often visible, and I am not aware who was the first discoverer of markings of this kind, but they are certainly of a distinctive and interesting character, and deserve more attention than they have hitherto received. I must confess, however, that I cannot altogether do away with the impression that they are an optical illusion. The spots to which these polar streams are attached are located in a latitude which is rather productive of discordant phenomena, and often displays a considerable amount of activity. It is in this north-temperate region of Jupiter that the swiftest and the slowest spot-motions have been determined, and these and other anomalies present a strange contrast to the behaviour of the south-temperate belt, which has preserved a very equable rate of about 9h. 55m. 18·7s. during many years.

Accompanying this paper are four representations of Jupiter—copied from drawings made at the telescope—and they will sufficiently illustrate the general aspect of the planet in July, 1902, and June, 1903, without presuming to critical exactness as to the positions in latitude.

Letters.

[The Editors do not hold themselves responsible for the opinions or statements of correspondents.]

"MOLECULES AND HEAT."

TO THE EDITORS OF KNOWLEDGE.

Sirs,—I would like to say a few words upon Mr. Edser's most fair criticism* upon my work on "Molecules and Heat." Writing upon the theory my experiments have suggested—I think proved—he states, "Such a theory labours under all the difficulties that beset the old caloric theory." There is a great difference between this new theory and the old caloric theory. My view is that the molecule is *not a constant in dimensions*. The old caloric and the kinetic theories regard the molecule as constant in dimensions. The fundamental fact—the all-important fact to be explained is: eliminating the change of state in the molecule—crystallization—any theory must explain why matter, especially liquid and gaseous matter, becomes lighter as it increases in temperature—for instance, hot water floats upon cold water. Now, my view explains this, but no other theory does.

Physical science is full of what appear to me to be contradictions in terms, which are believed in by men who carry my highest esteem. Speaking of the objects—spheres—I have shown floating in air, Mr. Edser says, "The accepted explanation of this depends on the fact that a gas or liquid exerts considerable friction on very small particles, which are thus unable to sink quickly." This I understand to mean, that there is contact between the gas or liquid molecules and these small particles to produce friction. Then he goes on to say, "The flask is filled with aqueous vapour, the invisible small molecules of which are comparatively widely separated from each other." A little thought will show that these two statements are a contradiction in terms. Now the views I have shown (which are derived wholly from experiment) give the friction Mr. Edser properly wants to import, and no other view does this. Then he repeats the wide-spread error, that the particles of dust in the air are centres of condensation, producing "small water droplets." Quite forgetting that experiment shows that such droplets gravitate, whereas the objects I have shown him *rise from the liquid*—in fact, dart off the liquid. To complete Mr. Edser's idea, we should see raindrops jumping up from the pavements and ascending to the skies, but who has ever seen such a phenomenon? Besides, I have shown experimentally that the particles of dust in the air are not the factors in condensation, for we obtain condensation without these motes, and with a single element, say, oxygen gas. Then Mr. Edser objects to the concept that "a water molecule as a spherical body composed of a *great number* of atoms of oxygen and hydrogen, in the proportion of one of the former to two of the latter," but goes on to say that this molecule consists of "one atom of oxygen and two atoms of hydrogen." Where is his authority for such a statement? He will reply that he obtains it from the chemist. But where is the chemist's authority? Absolutely he has no data, because if what I have shown is not the molecule, then no human eye has ever seen the molecule, and it is my audacity in stating that nature will show this object if we approach her with a neutral mind, which makes Mr. Edser say that "nothing could well be more startling than such a claim." The fact is, the deductions I have arrived at are built up from many more experiments than time permitted me to show Mr. Edser, especially experiments interpreted by the thermopile and the thermometer.

Frederick Hovenden.

West Dulwich, July 9th, 1903.

* Knowledge, 1903, page 160.

RARE CONDITION OF THE HUMAN HAIR.

TO THE EDITORS OF KNOWLEDGE.

Sirs,—Dr. Walter Kidd's note under this heading is interesting, but I hardly think he is warranted in concluding that the abnormal condition he describes may have been inherited.

It would be first necessary to ascertain that the part where the truncated hairs appear had not been subjected

to continued friction. In some observations of my own I found a similar condition of the hair on the outer part of the skin, and traced its cause to the person sleeping with legs crossed. In this case there was the additional peculiarity that, whereas some of the hairs had been regularly worn down to the skin surface, others had never succeeded in emerging from the skin, but had grown to a length of half an inch or more *beneath* the outer skin, through which they might be seen just below the surface. They could readily be lifted out with a needle point. Can Dr. Kidd suggest a cause for this mode of growth? Friction alone would hardly account for it, but perhaps pressure plus friction may have forced the hair point to take a right-angled course.

W. S. Rogers.

[The particular case referred to by Mr. Rogers, in which the hairs of the leg were found lying buried under the epidermis instead of projecting at an acute angle, is interesting, but I cannot see why any other force than that of the peculiar pressure exerted is required to account for the condition. I think friction would tend to prevent rather than favour the position of the hairs.

My own case is, of course, defective, as there is no evidence, except the man's own testimony, that it existed in early life. It is hardly possible that special friction or pressure could have been affecting for many years the two borders of each hand, and the middle of the dorsum of each be missed out, and the dorsal surfaces of the phalanges also affected. Besides which there were a few stray normal hairs of full length interspersed with the truncated hairs. But the situations where these truncated hairs were found are just those where the accumulated effects of repeated friction through many generations would be found, if at all.

It might be held that some unknown microbic or pathological origin could be assigned for the state of the hairs, but this is hardly possible, seeing how long the condition had lasted and that the skin was healthy and clean, and that normal were interspersed with abnormal hairs.

Walter Kidd.]

6th July, 1903.

THE CROSS OF S. SOPHIA.

TO THE EDITORS OF KNOWLEDGE.

Sirs,—I was abroad during April and did not see Mr. Antoniadi's rejoinder about the Cross of S. Sophia until I returned home. Mr. Antoniadi can hardly expect universal credence for his interpretation of the lines of the Silentiary's poem, which were so broken that neither Gräfe nor Bekker ventured to restore them. Moreover, the fragments quoted by Mr. Antoniadi (Knowledge, p. 91) do *not* state that the crown of the dome was adorned with a picture of Christ in Glory; they only say something about "mosaic" and "saving" and "guarding" and "the Saviour of the World." Such words are quite as likely to flow from the pen in describing a mosaic Cross as a mosaic Christ.

The "Painter's Manual" doubtless gives us the later praxis, but I never imagined that it was supposed to reflect the usage of pre-Iconoclastic days. No one doubts that a mosaic of Christ in Glory filled the centre of the dome in 1453 (Du Cange, p. 548; Lethaby and Swainson, pp. 278, 286), but there is nothing to suggest that this mosaic, or any other of the figure mosaics, is older than the Emperor Basil the Macedonian (867 A.D.). Messrs. Lethaby and Swainson may speak for themselves: "The figure scheme, so far as it can be traced, closely agrees with the Byzantine Manual of Painting; and the subjects and treatments can be associated with work in other churches of the ninth and tenth centuries which have in several cases almost identical designs. Altogether, it may be doubted if a single figure belongs to a time anterior to the Iconoclastic period of the eighth century. We believe the original scheme of decoration is best accounted for without figures, and even if this were not so, we can hardly believe that in the Patriarchal Church at the door of the Palace figures would have lasted through the reigns of the Iconoclastic emperors and patriarchs" (p. 280). "It is quite certain from Procopius and the poem of the Silentiary that the vaults of Justinian's church were covered with mosaic. They both describe the brilliance of the gold glittering surface, but do not mention any figures. In such detailed descriptions this silence goes far to show that there was originally no storied scheme of imagery, like that which the Poet so fully traced out on the curtains and iconostasis" (p. 282). Messrs. Lethaby and Swainson then go on to compare the Cross which they understand the Silentiary to describe at the highest point of the dome with the decoration of the well-known tomb of Galla Placidia at Ravenna, where the dome is covered with blue mosaic sprinkled with golden stars, and at the top is a golden Cross.

As to the translation of the lines about the *ἐρυσίπτολιν σταυρόν*, upon which the whole dispute hangs, I would ask those readers of Knowledge who have not already made up their minds, to consider the general plan of the Silentiary's poem, a plan which I venture to think inconsistent with a reference to an outside cross. Excluding the 304 lines on the Ambo, the poem on S. Sophia is 1029 lines long. Of these, the first 350 lines are introductory, and speak of the fall of the previous church and of the solemn inauguration of the present building on Christmas Day, 563 A.D. The last 109 lines are a panegyric on Justinian. The rest of the work, over 550 hexameters in length, is taken up with a detailed description of the *inside* of S. Sophia. The poet describes in turn the Eastern Apses, the Chancel Arch, the West End, the Narthex, the Four Piers that support the Dome, the Pendentives, the Cornice of the Dome, the Dome itself, the North and South Walls, the North and South Aisles, the Gynaecea, the Atrium, the Marbles, the Inlaid Work, the Capitals, the Floor, the Gold Mosaic, the Iconostasis, the Ciborium, the Altar, the Altar Curtains and the Pictures embroidered on them, and, finally, the arrangements for Lighting. But not a word is given to the outside. The description of the Lamps ends up with a declaration that the mariner, coming at night to Constantinople from the Ægean Sea, guides his ship not by the stars but by the lights of S. Sophia, shining through the windows in the lower part of the Dome.* Yet even here we are dealing with lights inside the church, not with an object placed on the outside. It is therefore wholly improbable that Paulus, while describing the inside of the Dome and comparing it to the vault of heaven, should suddenly pass through the tiles and tell us in ambiguous language of a cross on the outside of the Dome. Every other object mentioned by Paulus is visible from the inside.

Mr. Antoniadi has failed to bring forward any passage in which the verb *γράφειν* is used of sculpture or raised metal-work. The word is used of *writing* or *drawing*, in fact of any surface decoration. Thus in the Silentiary's Poem, ii., 232, *ἔγραψε* is used of designs made in marble inlay on the walls. But even granting that the primary meaning of *γράφειν* is "to scratch, to incise," few people would suppose that when Paulus says "a cross was scratched over the top of the dome" he really means "a

* Compare Mr. Antoniadi's charming drawing (Knowledge, p. 27).

cross was artfully carved out of metal and set up on the outside." Paulus evidently did not like to think of the Cross as plastered up against (ἐπί) the crown of the vault, though of course this was physically the case. His phrase seems to imply that he thought of it "as though it were suspended from heaven," to use the words of Procopius. Hence the employment of ὑπέρ—the Cross seemed not to be fastened upon the ceiling of the dome, but to be hanging over it.

In conclusion, I disclaim altogether any "desire to deprive mediæval Greek Churches of their outer cross," but I denied, and still deny, that the Silentiary mentions such a cross. And I am surprised that a writer who understands ἔγραφε to mean "artfully carved out of metal" should accuse my interpretation of artificiality.

F. C. Burkitt.

Elterholm, Cambridge.

P.S.—Since writing the above I have read Mr. Antoniadi's remarks on p. 102. The line from the Silentiary to which he refers (ii., 294) is ἄλλοθι δὲ χριστοῖο κατέγραφε μητέρα τέχνῃ. This refers not to a *statue* but to a *picture* of some kind, whether in incised metal or enamel or mosaic, or it may have been a wooden panel covered with metal plates. What I have denied, and still deny, is that γράφειν (or καταγράφειν) can be used for a detached object such as a standing cross or a statue. Or to put it into English, I deny that "to engrave" can ever mean "to set up."

The whole later scheme of decoration is fully treated by Lethaby and Swainson, as the extracts I have quoted sufficiently show, and I would refer readers of Knowledge once more to their book.—F. C. Burkitt.

[The reply to the various points raised by Mr. Burkitt is easy and obvious. In the first place he says that my quotation from the Silentiary (p. 91) does "*not* state that the crown of the dome was adorned with a picture of Christ." But in this he is mistaken, as the poet speaks, in his description of the dome, of "a circle," of "mosaic," and of "the Saviour of the World"; and as the cupola of St. Sophia has only one circle, the one formed by the ribs at the crown, any allusion to "a circle" and "mosaic" in the dome must necessarily refer to the crown. Then Mr. Burkitt asks us to believe that these words "in a circle," "mosaic," and "Saviour of the World," may have applied to a cross. This is a gratuitous supposition, and, considering that there is no mention whatever of a cross here, its conception has no counterpart in the world of fact, and cannot deserve serious attention.

Again, the quotation that "there was originally no storied scheme of imagery" in St. Sophia is opposed to evidence, as in the church of San Vitale, in Ravenna, built by Justinian, we find mosaic images of Christ, the Lamb, of angels, of Justinian and Theodora, and of a crowd of saints and apostles in great profusion. And if a provincial church was so richly endowed with eikons, is it not illogical to assume that the synchronous great central cathedral had no mosaic images whatsoever?

The evidence of the mausoleum of Galla Placidia has no bearing on the discussion, as there cannot be any comparison between the arrangements of a mere tomb and those of a great cathedral. Also, the attempt to preclude the Silentiary from describing any outer object of the church is contradicted by facts, since the poet describes in detail the open atrium, which, at variance with Mr. Burkitt's belief, formed an integral part of St. Sophia on the outside.

Mr. Burkitt says further that I have "failed to bring forward any passage in which the verb γράφειν is used of sculpture," when on p. 102 of the May number of Knowledge I have shown the poet to connect the form ἔγραψε with its subject λαοτόρος, stone-borer, or sculptor!

On p. 30 I remarked that the expression "*above* the highest summit" could evidently never apply to an inner cross—a difficulty which Mr. Burkitt never overcame. The late Mr. Swainson got rid of the obnoxious adverb, or preposition, by altering its meaning into *at*, but Mr. Burkitt has tried to reconcile it with an inner cross, the result being that he located his cross in the very thickness of the bricks (p. 84). This check did not discourage him, however, since he now ventures to conceive the accurate Silentiary to have meant that the cross floated above the position where it was depicted, although it is fair to add that Mr. Burkitt at once acknowledges the physical impossibility of his own assumption.

I am glad to see Mr. Burkitt admitting at last that γράφειν originally meant "to scratch, to incise"; and yet it is noteworthy that he triumphantly makes me mean that "a cross was *scratched* at the top," prudently avoiding to say that it was "*incised*," as the latter verb settles immediately this baseless discussion.

With regard to the last sentence of his letter, I support my interpretation of the words τέχνῃ ἔγραφε Σταυρὸν ὑπὲρ ἀκροτάτης κορυφῆς, "art *incised* or *carved* a cross above the most culminating summit," since the English verb *to carve* is etymologically akin to the Greek γράφειν, and because γράφειν was, according to the Silentiary, a function of the sculptor (p. 102).

On p. 84, Mr. Burkitt said that I brought "no evidence in support" of my "contention" that St. Sophia had a cross on the dome, like St. Paul's, asking me to convince him that there was such a cross. Now, considering that the need of conviction implies disbelief, Mr. Burkitt evidently deprived St. Sophia, and all Greek churches, of their outer cross. This was straining facts too much. Realising the gravity of such a situation, he now boldly refutes his primæval argument by disclaiming "altogether any 'desire to deprive mediæval Greek churches of their outer cross.'"

In short, my claim that the inner crown of the dome had a Justinian image of Christ becomes a fact, since it is confirmed by ocular witnesses at the time (p. 102), and this carries, of course, the cross outside; whereas Mr. Burkitt's mosaic cross, unseen by anybody, and resting on no facts, could naturally never step outside the bounds of subjectivity, throughout the present discussion.—E. M. Antoniadi.]

[In reply to his P.S., I thank Mr. Burkitt for having granted that γράφειν meant *to incise*; and as that verb, in English, means not only *to cut superficially*, but also *to cut right off*, we reach a demonstration of the fact that ἔγραφε was perfectly applicable to the solid cross of the dome.

The kindred verb χαράσσειν, to *incise*, is also used (p. 102) by the poet to say that a wall was *cut off* at a definite height.—E. M. Antoniadi.]

"COMETS AND THEIR TAILS AND THE GEGENSCHEIN."

TO THE EDITORS OF KNOWLEDGE.

Sirs,—I must protest against the assumption made in a review of the above work, in your issue for June, that my work constitutes a revival of Tycho Brahé's theory.

The refractive and consequent concentrative influences of the atmosphere of comets has not (previously to my work) been recorded. Even if any thinker had advanced similar views to mine, does this render the arguments I use any the less weighty or deserving of attention?

The writer of this review mentions a comet of 1823 and 1851. I can recall no comet of the former year, and

presume he is alluding to the comet of 1824. Unfortunately but little data is to hand as to these comets. Photography was not known. Were they to appear now, sufficient data could undoubtedly be collected either to confirm or disprove my theory. The only comet from which rays were apparently lying on the line of the "radius vector" was that of 1882, faint indications of which are discernible in the photographic views of this comet on November 7th, 1882. These photos were taken at the Cape, and a faint ray running into the head of the comet is distinguishable for a short distance from the head and *decreasing* in width as the rays leave the comet. In my own mind there is only one explanation for this luminous appearance, and it is that there must have been a comet travelling probably in the same ellipse and as an attendant body whose head was lost in the brightness of the sun but whose tail ran into the big comet on that date and was thus caught in these photos. This may or may not have been the case with the comets the reviewer wishes to quote. We have not, however, sufficient data to determine this point.

In conclusion, I must protest against the remarks that the reviewer has noticed several errors in my work. He only quotes two of the said mistakes, one obviously a printer's error, in which the year 1774 is printed instead of the year 1744. The other is no error, namely that *Donati's* comet was first discovered by Tuttle. I omitted to say "in America," and the meaning I had must be perfectly apparent by the text following the sentence, and also from my using the European discoverer's name. No other printer's errors exist and no other omission of words can be laid to my door in the whole of my work.

Fred. G. Shaw.

[Mr. Shaw's letter can hardly be said to strengthen his case. He says that he can recall no comet of the year 1823, but any astronomical work will inform him that a bright comet passed its perihelion on December 9th of that year. It was visible during the months of December, January and February, 1823-4. Hind referred to this comet as "remarkable for having exhibited a tail directed towards the sun in addition to another in the usual position." The fourth comet of 1851 presented a similar aspect, its tail "consisting of two branches, one of which was turned towards the sun." There are other instances, in spite of Mr. Shaw's assertion that the comet of 1882 supplied the only case of the kind. Your correspondent remarks that his statement "Tuttle discovered Donati's comet on June 2nd, 1858," was no error, only an omission of the words "in America." He evidently does not believe in errors of omission as well as errors of commission! Mr. Shaw's revival of old theories regarding comets' tails is never likely to exercise any weighty influence in explaining the phenomena recorded. The behaviour and occasional positions of the tails of comets would certainly suggest that they are NOT due to the action of refractive atmospheres surrounding the nuclei. A theory to commend itself must agreeably accord with observed facts, and will neither present serious discordances with them nor require us to adopt very improbable assumptions.—The Reviewer.]

Notes.

Astronomical.—The important part in cosmical phenomena which is probably played by the pressure due to radiation is receiving considerable attention at the present time. In 1873 Clerk Maxwell showed that if light be an electro-magnetic phenomenon, the absorption or reflection of a beam of light should produce a pressure, and he further computed the amount of this pressure. A year or two ago Prof. Lebeden, of Moscow, convinced himself of the existence of such a pressure, and found from his experiments that, within the limits of error, its amount was equal to that theoretically arrived at by Maxwell. A more complete investigation has recently been made by Professors Nichols and Hull, of Dartmouth College, U.S.A , and Maxwell's conclusion is again confirmed. It appears also that the radiation pressure depends only upon the intensity of the radiation. and is independent of wave-length, so that the long invisible waves are as effective in producing pressure as are the visible radiations. In attempting to apply this result to cosmical phenomena, it is to be borne in mind that while the gravitational attraction on particles varies with the centre of the radius, the repulsion due to radiation varies with the square of the radius, so that the ratio of repulsion to attraction will increase as the particles diminish in size; but a limit is reached when the particles are so minute that the radiation pressure is dispersed through diffraction phenomena. For this reason gases and vapours are not subjected to pressure from radiation, and the maximum ratio of radiation pressure to gravitation is about 20 to 1. The forms of comets' tails may be thus satisfactorily accounted for, the form depending on the size or density of the particles repelled from the head. Professors Nichols and Hull also describe an experiment for illustrating the formation of a comet's tail, and deal very fully with the whole subject in the June number of the *Astrophysical Journal*.—A. F.

Botanical.—The last number of the *Transactions of the Linnean Society* consists of an admirable contribution to our knowledge of insular floras in Mr. T. F. Cheeseman's "Flora of Rarotonga." Rarotonga is the chief island of the Cook group, situated in the Eastern Pacific, between the Tonga and Society Islands. Though discovered in 1821, and occupied by Europeans nearly the whole time since, scarcely anything has hitherto been published on its flora. The present paper includes an enumeration of the plants collected by the author during a three months' visit, made at the most suitable time of the year for studying the vegetation of the island. It is, therefore, practically a complete flora of the Phanerogams and Ferns. Rarotonga is of volcanic origin, and is about eight miles long and six broad. Near the sea there is a level tract of land, varying from a quarter of a mile to a mile in width, extending all round the island, while the centre is a mass of rugged mountains, ranging from 1575 to 2250 feet high. Forests abound, but the herbaceous vegetation, except numerous ferns, is scanty. With the inclusion of nearly one hundred species, which have with more or less certainty been introduced, the flora as at present known consists of three hundred and thirty-four vascular plants, of which no less than sixty-seven are ferns. Eighteen species belonging to sixteen natural orders are probably endemic. Perhaps the most remarkable plant amongst these is *Fitchia speciosa*, a new species of a curious genus of Compositæ, hitherto known only from the Society Islands, where three species are found. *F. speciosa* is common on all the mountains of Rarotonga. It is a small handsome tree, with fine glossy leaves and large orange-red flower-heads. The flora of Rarotonga resembles most closely that of the Society Islands, having one hundred and sixty-seven species in common, while one hundred and three of the same species are also found in the Tonga group.—S. A. S.

Zoological.—In a paper recently read before the Linnean Society, Mr. B. A. Bensley discusses the origin

and classification of marsupials. Too much emphasis, he believes, has been laid on the character of the dentition, and foot-structure is regarded as a surer guide for systematic arrangement. The ancestral forms were probably insectivorous; and from these evolution proceeded on two lines, one culminating in the herbivorous kangaroos, and the other in the carnivorous Tasmanian devil.

No. 475 of the *Proceedings* of the Royal Society contains an important communication by Dr. L. Rogers on the action of the poison of the sea-snakes. This venom is found to be much more virulent than cobra-poison, especially in its effects on fishes, which form the food of these reptiles. It acts by paralysing the nerve-centres, and, unlike cobra-poison, has little or no effect on the coagulating property of the blood. In the symptoms produced it is, however, very similar to cobra-poison, whence it is inferred that the latter also causes death by acting on the nervous system.

The same journal also contains a preliminary account of Miss Bates' discovery in the superficial deposits of Cyprus of remains of pigmy elephants closely allied to those so long known from Malta. The Cypriot form is regarded as a distinct species, but it may be a question whether it is more than a variety. When fossil elephants were discovered in Malta, it was a practical certainty that they would turn up in the other Mediterranean islands, if only there were deposits suitable for the preservation of their remains.

The various American races of reindeer, or caribou, are admirably described and contrasted in an article contributed to the Seventh Annual Report of the New York Zoological Society by Mr. M. Grant, the Secretary. The author is of opinion that all, or nearly all, of the existing Old World reindeer are allied to the American Barren Ground caribou; but since antlers resembling those of the woodland race are met with in the superficial deposits of S. Europe and Asia, it is considered probable that the latter animal reached America from Asia by way of Bering Strait.

The May issue of the *Quarterly Journal* of the Geological Society contains the full account of the remains of mastodons and sabre-toothed tigers recently discovered in a Derbyshire cave of Pliocene age. It appears that this important discovery was made accidentally by a schoolboy, who picked up some mastodon teeth among the *débris* from a quarry; unfortunately many other teeth were buried deep in the talus. This discovery should convince those who argue that the Crag mastodons were not natives of Britain of their error.

A bulky memoir on the mummified animals of ancient Egypt appears in the eighth volume of the *Archives* of the Museum at Lyons, by Messrs. Lortet and Gaillard. An extraordinary large number of species—both wild and domesticated—have been identified from their mummified bodies; among the latter being the bubal, or lesser hartebeest (*Bubalis boselaphus*), and the arui, or North African wild sheep (*Ovis lervia*).

The Earthquake of June 19th.—Three months ago we recorded the occurrence on March 24th of an earthquake in the west of Derbyshire, strong enough to cause some slight damage to buildings and to disturb an area of about 13,500 square miles. This was followed on June 19th, at about 10.8 a.m., by a shock which, if it resulted in no loss to property, affected a still wider area. It was felt along the east coast of Ireland and for some distance inland, from Wexford to several miles north of Dublin. In the southern half of the Isle of Man it was distinctly perceptible, and was at once recognised as an earthquake shock. On the other side of the Channel the disturbed area includes the whole of North Wales, and probably the greater part of the principality, although no records are as yet forthcoming from the counties of Pembroke and Glamorgan. In England the shock was noticed as far east as Warrington and at several other places in Lancashire. Thus, even if we exclude isolated records from places so far distant as Belfast and Kendal, the disturbed area can hardly have been less than 220 miles long from north-east to south-west and 170 miles wide, and must have contained about 30,000 square miles. The district most strongly shaken was a band embracing the west coast of Carnarvonshire from Nevin to between Carnarvon and Bangor, and the centre was probably not far from Clynnog, though whether under land or sea it is at present difficult to say. The principal shock appears to have been simple in character and of unusual duration. At Birmingham it was registered very clearly by a horizontal pendulum designed by the distinguished Japanese seismologist Prof. Omori. The last earthquake of any consequence originating in this district was one that occurred on November 9th, 1852, and disturbed an area of about 70,000 square miles, including parts of all four kingdoms.

British Ornithological Notes.

Conducted by Harry F. Witherby, F.Z.S., M.B.O.U.

Black-winged Pratincole (Glareola melanoptera) in Kent.—At the June meeting of the British Ornithologists' Club, Dr. N. F. Ticehurst exhibited a male specimen of this Pratincole. The bird was shot by Mr. F. Mills, in Romney Marsh, in May last. This species of Pratincole has not been recorded before from the British Islands. It differs from the Collared Pratincole in having black instead of chestnut under-wing coverts and axillaries.

Collared Pratincole (Glareola pratincola) in Kent.—At the same meeting, Dr. Ticehurst exhibited a male specimen of this Pratincole, which had been shot very near the same place as the above, on May 30th, by Mr. Southerden. This bird breeds commonly in southern Europe and North Africa, and occurs now and again in Great Britain, but it has not been recorded before for Kent.

Blue-headed Wagtail (Motacilla flava) breeding in Sussex.—In 1901, Mr. Ruskin Butterfield recorded that a pair of these birds had nested in Sussex (*see* Knowledge, 1901, p. 281). At the June meeting of the British Ornithologists' Club, Dr. Ticehurst exhibited a nest and eggs of this species, taken on May 21st last, within twenty yards of the spot where the 1901 nest was taken. With these two records, and the evidence of a regular migration of these birds on the coasts of Kent and Sussex (*see* Knowledge, January, 1903, p. 12), the Blue-headed Wagtail has become more than a chance visitor to our shores.

White Wagtail in the West of Ireland.—The White Wagtail has been observed to visit Co. Mayo in the month of May for six years in succession, and a further proof of the migration of this species up the west coast of Ireland is afforded by Mr. R. M. Barrington, who now records the presence of these birds on the coast of Donegal last May.

Early Arrival of Swallows in Ireland. (*Irish Naturalist*, 1903, July, p. 198.)—Mr. R. J. Ussher remarks that Swallows are seldom observed in Ireland before April, but that this year they appeared over a wide area in March.

Woodchat Shrike in Yorkshire. (*The Naturalist*, 1903, July, p. 262.)—Mr. C. G. Danford records that he saw a Woodchat Shrike on May 9th at Speeton. The Woodchat rarely visits England.

Hawfinch in North Dumfriesshire. (*Annals Scot. Nat. Hist.*, 1903, July, p. 184.)—An adult male Hawfinch was picked up dead near Kinnelhead on April 6th last. The bird is rare in Scotland.

Grey-headed Wagtail (Motacilla viridis, Gmel) in Yorkshire and in Sussex.—At the May meeting of the British Ornithologists' Club, three adult male specimens of this Wagtail were exhibited. One was caught in a lark net at Halifax, Yorkshire, in the spring of 1901, and was exhibited by Mr. W. E. de Winton on behalf of Mr. W. Eagle Clarke. The two other specimens were shot near Willingdon,

Sussex, on May 13th last, and were exhibited by Mr. Ruskin Butterfield. This Wagtail, which is also known under the name of *M. borealis*, Sundev., is much like *M. flava*, but has the head blackish-grey instead of ashy-blue. The Grey-headed Wagtail breeds in northern Europe and Siberia, and migrates to South Africa and India. Two specimens are said to have occurred at Penzance, but the above are the first authenticated records of its occurrence in the British Islands. Judging by its distribution, one would have expected this Wagtail to have occurred more often on our eastern seaboard.

Black-headed Wagtail (Motacilla feldeggi, Michah*) in Sussex.*—At the same time and place as the two Sussex specimens of *M. viridis* were obtained, an adult male of *M. feldeggi*, Michah, or *M. melanocephala*, Licht., was shot. This Wagtail has a black head, and is altogether a darker and more richly coloured bird than *M. viridis.* It also winters in Africa and India, but its summer haunts are in south-eastern Europe, Persia, and Central Asia, so that it can never be regarded as anything more than a straggler to these islands.

All contributions to the column, either in the way of notes or photographs, should be forwarded to Harry F. Witherby, *at the Office of* Knowledge, 326, *High Holborn, London.*

Notices of Books.

"The Soil: An Introduction to the Scientific Study of the Growth of Crops." By A. D. Hall. Pp. xiii. and 286. (Murray.) Illustrated. 3s. 6d.—Agriculture in England is usually practice without science; and agricultural science, on the other hand, often neglects the results obtained by generations of farmers in their fields. Mr. Hall, we are glad to notice, recognises the value of the accumulated experience of the farming community, yet he shows that the study of the soil as a complicated laboratory in which chemical, physical and biological agents are at work, is the only sure means by which tillage operations can be improved. "But," he remarks, "it must not be supposed that science is yet in a position to reform the procedure of farming, or even to effect an immediate increase in the productivity of the land; agriculture is the oldest and most widespread art the world has known, the application of scientific method to it is very much an affair of the day before yesterday." This is the opinion to which every man of science who knows anything of farmers and farming is bound to be led. Mr. Hall's book may only be read by a few people engaged in agriculture, but it is one which every student in an agricultural college should be expected to buy. We know of no volume in which the constitution and work of the soil are dealt with so instructively, for though Warington's "Physical Properties of Soil" is a standard treatise, its scope is not so wide as that of the volume under notice. Mr. Hall is indeed to be congratulated upon his book, which contains many original observations, and is in other respects a noteworthy addition to the literature of agricultural science. We miss, however, reference to Schlichter's memoir on the motion of underground waters, though it contains the results of important investigations connected with sewage in soils.

"Chemical Technology." Vol. IV. Edited by W. J. Dibdin. "Electric Lighting," by A. G. Cooke. "Photometry," by W. J. Dibdin. Pp. xviii. and 378. (J. & A. Churchill.) Illustrated. 20s.—One hundred pages of this book deal with photometry, and in the remainder the various systems, machinery, lamps, &c., in use for the supply of electric lighting are described. The book is not intended for students of physics, or for electrical engineers, but for architects, civil and mechanical engineers, and other professional men who wish to obtain a general idea of the practical side of the subject. Principles are therefore not given so much attention as their applications. At the same time, sufficient consideration is given to scientific theory to enable an intelligent view to be obtained of the construction and working of electrical machinery, the distribution of current, and the determination of candle power. The conditions under which commercial work is carried on differ from those of the laboratory, and the fact that Board of Trade regulations are introduced wherever they bear upon the matter described helps to make the book of real practical value. Of course, it is impossible to obtain an intimate acquaintance with dynamos, storage batteries, electric lamps, photometers, and the like, without actually using them; but anyone who has had the opportunity of studying electrical plant of any kind should have no difficulty in understanding all that the book contains. Photometry, as might be expected, is very well treated, practically every instrument of importance being described. An appendix giving the "Metropolitan Gas Referees' notification of method for testing the gas supplied to London" is of special interest in connection with the competition between gas and electric lighting.

"Experiments on Animals." By Stephen Paget. With an Introduction by Lord Lister. Pp. xvi. and 387. (Murray.) Price 6s.—This book should do a vast amount of good. In its original form it contained many references to misleading comments made by anti-vivisection societies, but these have been omitted, and the book is now a calm statement of progress in medical science, more particularly preventive medicine, from Galen to the present day. Galen, who lived in the second century, made many valuable observations by experiments on animals, but the methods followed by him were not continued by his successors, and though the knowledge of anatomy made progress, physiology remained as Galen left it until the time of Harvey's discovery of the circulation of the blood in 1628. After this came the discovery of the lacteals and of the whole lymphatic system, experimental studies of the digestive processes, the production of bone, and the physiology of the nervous system. The first part of Mr. Paget's book is occupied with the record of these advances. In the second part, experiments in pathology, materia medica and therapeutics are described, and the third part contains a reprint of the Act relating to experiments on animals in Great Britain and Ireland. Modern medical sciences may almost be said to be confined to the second part. Here we have clear and convincing summaries of the work of benefactors of the human race like Pasteur and Lister, and readers who are not familiar with the progress of preventive medicine during the last fifty years will when they have learnt what has been done, bless the men whose work, often carried on against bitter opposition, has enabled us to fight disease intelligently. Consider what has been done to prevent and combat septicæmia, pyæmia, anthrax, diphtheria, rabies, malaria and yellow fever during the last fifty years, and you will obtain a slight idea of the benefits which mankind has received from experimental methods in medicine. Want of knowledge of what has been done is responsible for much of the opposition to the experiments by which the results have been obtained. With Mr. Paget's clear and judicious statement available, there should be no excuse for ignorance, and no want of an answer to those who ask for evidence of the value of experimental medicine.

"Variation in Animals and Plants." By Dr. H. M. Vernon. Pp. ix. and 415. (Kegan Paul.) Illustrated. 5s.—Natural history is becoming a branch of mathematics, and whatever field naturalists may think of the development, there can be no question of the substantial nature of the results obtained in the new department of scientific inquiry. Francis Galton, Karl Pearson, Weldon, and others, have laboriously counted, weighed, and measured animals and plants of various kinds with the view of discovering the character and cause of variation; and an energetic school of biologists—Dr. Vernon among them—has been established in which their methods have been followed with success. In the volume under notice, the principles and results of bio-metric investigations are brought together, and their significance from the point of view of organic evolution is discussed. As an instance of the nature of the material thus studied, Prof. Bumpas's paper on the effect of storm on sparrows may be mentioned. One hundred and thirty-six sparrows were collected after a very severe storm of snow, rain, and sleet in North America, and of these 72 revived, while 64 perished. Measurements of each sparrow were made with the view of determining differences in the characters between the eliminated individuals and the survivors. The results showed clearly that the birds which departed most from the normal type were destroyed by the process of natural selection. Summing up the observations, Dr. Vernon remarks, "The next generation of birds collected in the storm-swept area would accordingly be shorter in length, weigh less, have longer legs, have a longer sternum, and a greater brain capacity than the former generation; supposing, of course, that the variations existing in these characters were partly of blastogenic, and not wholly of somato-

genic, origin; and this could scarcely fail to be the case." An immense amount of material which lends itself to exact analysis in this way is contained in Dr. Vernon's book, and it all tends to promote the scientific study of variation. The volume is a most valuable contribution to the literature of natural science.

"Geometrical Optics." By Thomas H. Blakesley. Pp. vii. and 123. (London: Whittaker & Co. 1903.) 2s. 6d. net. Illustrated.—Students of optics will find many instructive and original ideas in this book, though the prime object of its publication appears to be a protest against the definition of focal length usually accepted. The focal length of a lens is defined in many books on optics as the distance of the principal focus from the posterior surface of the lens, but this definition is unsatisfactory, and Mr. Blakesley fathers upon it many imperfections of optical instruction, design, and testing. Lenses which have a negative value for their focal length are considered in general as convex lenses, while those which have positive focal lengths are regarded as concave; but these terms are shown to be illogical because "a double convex lens of equal curvatures, if sufficiently thick, will have a positive value for its focal length with the general properties of a concave lens." By measuring distances of object and image from the first and second principal foci instead of the principal points, difficulties are avoided; and simple mathematical forms are developed which are true not only for a simple lens, but also for two or any number of lenses having a common axis. Novel optical experiments are described for determining the positions of the principal foci and the focal length, and formulæ are given, which, with a knowledge of the thickness of the lens, enable all the remaining structural details to be found, namely, the two radii of curvature and the index of refraction. The book should be the means of increasing the precision with which optical details are measured and expressed.

"Natural Law in Terrestrial Phenomena: A Record of Evidence." By William Digby, c.e. Pp. xlv. and 370. (London: W. Hutchinson & Co.) Illustrated.—No useful purpose would be served by a detailed criticism of this book, so we will briefly describe the chief points put forward, for whatever we might say concerning the theories described would be regarded as opposition which traditional schools of scientific thought present to novel ideas from laymen. The book contains a detailed statement of Mr. Hugh Clements's theories and predictions relating to weather and other terrestrial phenomena. "I believe," says Mr. Digby, "that the succeeding pages of this book prove that the moon's attractive influence exerted upon the earth's atmosphere, in conjunction with the sun, accounts, in the main, for all weather phenomena." For particular positions of the moon and sun jointly, certain conditions of weather are prescribed, so that weather prediction becomes an easy form of study of orbital movements. To avoid misrepresentation we quote from the formula upon which Mr. Clements bases his forecasts. "Thus it follows that barometric pressure, increase or diminution of clouds, much or little sunshine, an overplus, an average, or a scanty supply of rain, earthquake-shocks, volcanic eruptions, will all occur in time to come as they did in times past, so long as, in the case of shocks and eruptions, weak spots remain in the earth's crust." It would be easy to offer objections to many parts of the argument upon which this conclusion is based, but we will confine ourselves to one point. It is that human interference is a factor which makes it impossible to reduce weather prediction to the mechanical conditions described. A man drops a lighted match on a dry prairie, or leaves the smouldering embers of a fire in a forest. A great conflagration occurs which may disturb the atmospheric currents for hundreds of miles. It is impossible for Mr. Clements or any other meteorologist to predict the effects of this and similar disturbing causes. But Mr. Clements may rest assured that if his theories are true they will survive scientific opinion; if, however, as we think, they are unsound, they will eventually be relegated to the limbo of the paradoxers.

"Volcanic Studies in Many Lands." By Tempest Anderson, m.d., f.g.s., etc. (Murray.) 21s. net.—Dr. Anderson is so well known as a photographer of and student of volcanic forms that this handsome book cannot fail to meet with a hearty welcome. Readers of Geikie's "Ancient Volcanoes of Great Britain" and of Bonney's "Volcanoes" are already familiar with his work, and, through Dr. Anderson's courtesy, we were enabled to reproduce two of his recent photographs of Mont Pelée in Knowledge for last November. The present volume is the result of expeditions made during the last eighteen years to Vesuvius and Etna, the Eifel and the Auvergne, the Lipari Islands, the Canary Islands, Iceland, and the West Indies, as well as to various regions in Britain and North America, in which volcanic action has for long ages been extinct. It contains more than a hundred plates, each accompanied by a short description. The photographs from Iceland, Rhenish Prussia, and St. Vincent are, perhaps, of exceptional interest; but the whole series is unrivalled in the illustrations it affords of the various details of volcanic structure.

"Tsimshian Texts."—From the Smithsonian Institute we have received a copy of a volume (No. XXVII.), of the *Bulletin* of the Bureau of American Ethnology, devoted to the elucidation of the so-called Tsimshian Texts. by Mr. F. Boas. Although the transcript of these texts is doubtless of much interest and importance to the students of folk-lore, it is not of a nature to attract the majority of our readers. We must therefore pass over the volume with this bare mention.

BOOKS RECEIVED.

British Rainfall, 1902. By H. Sowerby Wallis and Hugh Robert Mill, d.sc., ll.d. (Edward Stanford.) 10s.

The Junior Arithmetic. By R. H. Chope, b.a. (University Tutorial Press, Limited.) 2s. 6d.

Sand-Buried Ruins of Khotaw. By M. A. Stein. (T. Fisher Unwin) 21s. nett.

A Short Manual of Analytical Chemistry. By John Muter, ph.d., f.r.s.e., f.i.c., f.c.s. (Baillière, Tindall & Cox.) 6s. nett.

The Structure of the Nucleus. By Carl Barus. (Smithsonian Institution.)

Etude Sur L'Appareil Circumzénithal. By Fr. Nusl et Josef Jan Friě. (L'Académie des Sciences de L'Empereur François Josef I.)

A Brief Course in Qualitative Chemical Analysis. By John B. Garvai, b.s. (D. C. Heath & Co.) 3s. 6d.

Elements of Physics. By Fisher and Paterson. (D. C. Heath & Co) 2s. 6d.

Ways of the Six-Footed. By A. Botsford Comstock. (Ginn & Co.) 2s.

The Truth about the Egypt Exploration Fund. By William Copley Winslow, d.d., d.c.l., ll.d.

Meteorological Observations made at the Perth Observatory and other places in Western Australia, under the direction of W. Ernest Cooke, M.A., F.R.A.S., Government Astronomer. (W. A. Watson.)

An Introduction to Botany. By Wm. Chase Stevens. (D. C. Heath & Co.) 6s.

Elementary Physiology and Hygiene. By Buel P. Colton, m.a. (D. C. Heath & Co.) 2s. 6d.

Lectures and Essays. By Professor Tyndall. (Watts & Co.) 6d.

The Insect Folk. By Margaret Warner Morley. (Ginn & Co.) 2s.

Higher Criticism as Applied to Itself. By Artemus Longsides, m.a. (Authors and Booksellers Co-operative Alliance, Limited.) 1s.

Radiant Energy and its Analysis. Illustrated. By Edgar L. Larkin. (Baumgardt Publishing Company.)

Astronomy for Everybody. By Simon Newcomb, ll.d. (Isbister & Co.) 7s. 6d.

A Naturalist's Calendar. By Leonard Blomifield. Edited by Francis Darwin. (C. J. Clay & Sons.)

The Popish Plot and its Newest Historian. By the Rev. John Gerard, s.j. (Longman, Green & Co.) 6d.

The Reliquary. By J. Romilly Allen, f.s.a. (Bemrose & Sons, Limited.) 2s. 6d.

The Burlington Magazine. No. 5. (Savile Publishing Co.) 2s. 6d.

Nurses and Nursing, or How not to do it. By Sister Medicatrix, Ex-N.S. (The Authors and Booksellers Co-operative Alliance, Limited.) 6d.

Booklet on *Goerz Trieder Binoculars.* C. P. Goerz. Free.

Water and Air, or New Thoughts on Old Subjects. By J. P. Sandilands, m.a., t.c.d. (The Authors and Booksellers Co-operative Alliance, Limited.) 4d.

Das Zeisswerk und du Carl-Zeiss-Stiftung in Jena. By Felix Auerbash. (Gustav Fischer.)

List of Second-Hand Instruments. C. Baker. Free.

Urban Film Subjects. The Charles Urban Trading Co. Free.

Quacks and What they do. By One of Them. (Authors and Booksellers Co-operative Alliance, Limited.) 6d.

The Wellcome Physiological Research Laboratories. (Walter Dowson, Director.)

Geological Rambles in East Yorkshire. By Thomas Sheppard, f.g.s. (A. Brown & Sons, Limited.)

THE STRUGGLE FOR EXISTENCE IN SOCIOLOGY.

By J. Collier.

II.

The Marital Struggle.

At a date beyond the oldest history, for we find traces of the division in all but the lowest peoples, the "order" of the family split into two great genera, which MacLennan happily named endogamy and exogamy, or marriage within the clan (not the tribe) and marriage without the clan. The struggle between the two is the tragedy of barbaric races. It leads incessantly to war among them, as it led to war in ancient Troy, and as it has led to war in modern Morocco within the last few years. All through the European Middle Ages the two forms battled against one another. The Greek Church upheld, and still upholds endogamy, by permitting marriage between uncles and nieces. The Catholic Church ensured the victory of exogamy in Western Europe by refusing permission to marry wherever the most distant relationship could be traced between the parties. Some of the most questionable acts of the Papacy were done in avowed defence of the principle, and the most frivolous pretexts were accepted for dissolving marriages of royal persons between whom some relationship was alleged. Yet it has more than once yielded to endogamy by celebrating the marriages of uncles and nieces, as not long ago of an Italian royal duke and his niece.

Under Protestantism, which breaks down many barriers, endogamy has recovered some of its lost ground. Cousins may lawfully intermarry, though the scientific battle rages round the point of prudence. Still, a wholesome exogamy remains everywhere the conquering type, and in our own days it has received a new extension through the marriages of the daughters of American millionaires to European noblemen. Endogamy survives or survived in spots or spheres removed from the action of natural selection; in out-of-the-way villages, in fishing and mining quarters of towns, and on thrones, as on those of the Ptolemies and the Braganza.

Exercising the privileges of an Englishwoman in the middle of the eighteenth century, Lady Mary Wortley Montague gained access to the harems of Constantinople, and let in the light of day upon Oriental wedlock. A century later the Princess Belgiojoso revealed the mingled squalor and animalism of the Anatolian harem. A few years ago a French cosmopolite, C. de Varigny, described courtship, marriage, and divorce in the United States as an anthropologist might describe the manners and customs of a strange people. These are the two extreme forms of the marital relationship; is it credible that there can be any genetic connection between them? Yes, the one is the remote ancestor of the other, and between the two—between incestuous polygamy, as lately practised in Salt Lake City, and the purest monogamy, as observed in neighbouring Denver—there is an unbroken chain of descent, of which almost every link can be discovered. Indeed, most of the intermediate species and varieties are our contemporaries, and an inclined plane would let the sociologist easily down from Boston to Bassorah.

Thus, the Bosnian Mussulman, who is pure Sclave, has yet his separated harem, where his one wife lives sequestered. The Greek woman is still rarely seen on the streets; commerce is hampered because she cannot become a shop-assistant; the harem has disappeared, but the husband's Oriental jealousy remains. The status of the upper-class Spanish woman is stamped with Orientalism, though the cigar factories at Seville are filled with girls and women. French marriage reveals its barbarous origin in the universal dowry, the requisite consent of the parents, and their choice of the bride. The English wife is, in the middle and upper classes, almost her husband's equal. The Australian and New Zealand wife, who has a vote for Licensing Committee, County Council, State, and Commonwealth, has the equality and something more that derives from a time (only now passing away) when her small numbers permitted her to make her own terms. The North American wife is a queen, whom over-chivalrous laws are converting into a sultana.

All these varieties and species are constantly (in a sense) at war with one another. Thus (to take a present-day instance), the controversy between the Bishop of London and his Chancellor represents the struggle between the sacred and the secular types of marriage. When the Bishop of London announces that he will visit no church where divorcees are remarried, he commits an act of war against the type of marriage legalised by the State. Great part of the Anglican clergy, both in England and the colonies, is thus at war with the State.

In the United States, the struggle among the many varieties is reflected in the legislation of the States. The prosperity of a State depending on the increase of its population, and emigrants having usually an independence of character that will brook few restraints, each State seeks to attract settlers by abolishing formalities, simplifying all social acts, and especially by facilitating both marriage and divorce. Hence a conflict of laws extending over the entire territory of the Union. According to the State he resides in, a man is married to a woman or divorced from her, married to a woman or never married to her at all. In virtue of the practice of "limited divorce," a woman may be receiving alimentary allowances from two or three former husbands, while she is living with a third or fourth. The way in which a man, without his intention and by some innocent act, becomes, in Persia, the legal husband of a woman, is a subject for comedy, in certain American States it may be matter of tragedy, and in any case it is part of the written law.

A new species of marriage comes in like a new species of plants or animals. A high authority, the late Lewis Morgan, who naturalized himself as an Iroquois in order to study the development of the Indian family, believed that the passage from one domestic type to another was effected by means of a "reformatory movement." The most normal evolution is never quite regular; even the growth of a language takes place by disruptions and breaches of continuity, and the history of the family reveals many a struggle. But if it is implied that, once upon a time, some one individual or some group, perceiving the disadvantages of the old and the advantage of a new type of marriage, deliberately introduced a new system, the view must be pronounced anti-evolutionary. A modern instance is typical. The first man who married his deceased wife's sister was the progenitor of a new variety. A few slowly followed his example. The old type showed fight by inflicting on them a social ban so severe that many women refused to marry their deceased sister's husband. As the numbers of the innovators grew, they gained friends, and a Bill was introduced into Parliament. After a succession of battles it was carried in the Commons; had it been carried in the Lords, the new variety would have conquered, and such marriages would have become numerous. In the British Colonies, where the forces of resistance are far feebler, the struggle was brief, and the old type was defeated along great part of the line; though Anglican and Catholic priests may for a time refuse to recognize it by refusing to celebrate such marriages. It is the history in a nutshell of the rise of polyandry, polygamy, and monogamy.

The Agrarian Struggle.

In many countries the tenure of land has been the theatre of a conflict. It would be interesting to follow, for example, the vicissitudes of the battle in France during the nineteenth century between *métayage* and *fermage*, or of that other battle between large estates and peasant properties; but either topic would lead us too far afield. A more manageable subject, of more pressing interest and susceptibile of exact statement, invites attention.

By the right of eminent domain, by purchase or confiscation, the Government of a new colony acquires the fee-simple of whole territories. How shall it dispose of them to eager settlers? It sells them to those rich enough to buy, but many eligible farmers lack sufficient means. Then springs up in rapid succession a variety of tenures whose primary object is to facilitate settlement. That the struggle for existence among sociological species arises from the same cause as the struggle among biological species—the number of forms competing in the same area —appears from the fact that, if New South Wales has flowered into sixteen varieties of land tenure, New Zealand luxuriates in nineteen. The experimentation took on a new character after the advent of Henry George. From that moment the disposition was to retain the ownership in the hands of the State, lightly burdening the tenant with a quit rent. The perpetual lease was the first new tenure. Perpetuity might seem to promise as great a duration as a farmer could wish, but the New Zealand land reformer (the Highland shepherd boy who lately died Sir John Mackenzie) stole a march on time and invented the eternal—which its opponents nicknamed the infernal —lease, or lease in perpetuity. The new school holds that the Cosmos is finite, and an eternal lease lasts for only 999 years. Thus, granting fixity of tenure, and carrying with it the power of sale, sublease, mortgage, or disposition by will, it is practically equal to freehold. On the other hand, a low rental of 4 per cent. on the assessed capital value retains the property for the benefit of the State, while a land tax secures for it the "unearned increment." A tenure with all these advantages would seem destined to prevail. Other tenures are accordingly being abandoned in favour of the lease-in-perpetuity. Thus, to take a single instance, in the province of Otago perpetual leases decreased in 1900-01 from 301 to 286, and the area held from 58,538 acres to 55,510 acres. The reduction arose from conversion into leases-in-perpetuity or into freehold. For settlers are manifesting an unmistakable bias in favour of individual ownership. So recently as September last a motion was made in the House of Representatives authorizing the conversion of leases-in-perpetuity into freeholds. The Minister of Lands strenuously resisted the proposal; but the movement shows the tendency of this brand-new tenure to lapse, like the older forms, into freehold. Other evidence is to the same effect. During the year named 195 holders of the old perpetual leases converted their leaseholds into freehold; and the provincial Commissioners testify to the growing popularity of the optional lease systems. Thus, in Taranaki, the occupation-with-right-of-purchase tenure assumes the lead against lease-in-perpetuity by 39 selectors. It is safe to predict that, within a measurable space of time, all tenures will have disappeared, and freehold will reign alone.

Such are the relations among sociological species which the property of language, or the dominance of a particular mode of thought, obliges us to name by terms softened from those descriptive of a bodily encounter. But there is no actual struggle among such species, any more than there are mortal wounds or rivers of blood. Endogamy may be said to die at the hands of exogamy, and State-tenure at the hands of freehold, but only by a questionable extension of a convenient metaphor. Mr. Spencer's felicitous phrase, which even the universal learning of Dr. Garnett attributes to Darwin, more truly describes the result, without always satisfactorily describing the process. It is, indeed, the fittest that survive, but the laws of adaptation remain to be generalized. The world is not a battlefield. Some great new thinker will supply us with a new nomenclature, or will strip our present terminology of misleading associations.

MICROSCOPY

Conducted by M. I. Cross.

POND-LIFE COLLECTING FOR THE MICROSCOPE.

II.—Apparatus for Microscopic Examination.

By Charles F. Rousselet, F.R.M.S.

Having shown in a previous article how to collect the various Pond organisms, I will now discuss those methods of bringing them under the microscope which I have found both practical and expeditious.

Fig. 3 is a photograph of various apparatus used for this purpose, consisting of troughs, pipettes, live box and compressor.

After capturing a miscellaneous collection of Pond-life and transferring it to a window aquarium, placed in front of a window, as previously explained, it will be desirable first of all to place some of it under a low power of the microscope, say a 2 inch or $1\frac{1}{2}$ inch objective, in order to obtain a better general view of the various animals. The free-swimming forms will mostly have collected on the light side of the aquarium, and can there be picked up quite clean, and in vast numbers sometimes

Fig. 3.—Micro. Troughs, Pipettes, Live-box, and Compressor, for Pond-life work.

with the pipette (e) and transferred to a square trough (a) or (b), and placed under the microscope, where the contents can readily be illuminated from below, both with transmitted light and under dark ground. I prefer to use dark-ground illumination with low powers when searching over the contents of a trough, and when studying the shape, mode of swimming, ways of feeding and living of Polyzoa, Rotifera and Infusoria. Moreover, the animals scattered through the trough will soon collect in the spot of light of the condenser, and then the whole field of view will often be a mass of moving, dancing, tumbling, sparkling life.

The trough (a), 3 inch by $1\frac{1}{2}$ inch and $\frac{5}{16}$ inch thick, is the form I mostly use; it stands upright on the table, is reversible and can be handled without greasing the well part of the glass. The

sides are cemented in the fire by means of a fusible glass cement, and thus the trough is and remains watertight. The trough (*b*) is also a useful type but it is not reversible, will not stand by itself on the table, and, being cemented with gold size or marine glue, is liable to leak. The troughs usually sold are semi-circular in shape, a very bad type, because in addition to the above defects, the least amount of tilting on the stage will cause the water to run out over the edge. Thicker troughs are objectionable because the substage condenser cannot work through them, and the animals cannot be properly illuminated, though sometimes such troughs may be required by the size and nature of the object.

A few words on pipettes will not be out of place here. The old-fashioned way of using the finger on a straight or curved glass tube to capture Pond-life is so unsatisfactory that I have been driven to invent new pipettes for more precise and exact work. Fig. 3 (*c*, *d*, and *e*) represent the pipettes in constant use. (*e*) is a glass tube about $\frac{5}{16}$ inch in diameter and 8 inches long, which tapers from the middle to a point more or less fine, according to the size of the animals one wishes to capture. Over the wide end is placed an indiarubber teat, by means of which any single specimen, or scores of animals, can be sucked up with the least quantity of water. (*d*) is another type of pipette, having a still finer action; it is 6 inches long, funnel-shaped at one end, and tapering gradually from the funnel to a fine point; the funnel is $\frac{3}{4}$ inch wide, and covered with an indiarubber membrane. (*c*) is a similar, but smaller and finer pipette, 3½ to 4 inches long, for picking up small Rotifers in a fraction of a drop of water under the dissecting microscope. The slightest touch on the membrane is sufficient to expel or bring in the water, so that one has complete control over the amount of water that is taken up, and there is much less risk of losing the animal one wishes to transfer to the compressor.

The old-fashioned live box with raised tablet, still largely sold with microscopes, is quite useless for Pond-life, for the simple reason that the objects cannot be properly illuminated with the substage condenser. This consideration led me long ago to design the live box (*f*), in which the glass tablet is fixed flush with the brass plate, and is of small size, thus leaving a wide ring all round. This arrangement allows all objects on the tablet to be perfectly illuminated from below by the achromatic condenser, both with transmitted light and under dark ground, and at the same time they can be reached and followed from above with both low and high powers, and oil-immersion lenses, to the very edge of the tablet, and wherever they may wander. For more exact work, when it is desired to hold a single Rotifer between the two glasses and prevent its wandering about, I have devised the compressor (*g*), in which the pressure, and the thickness of film of water, can be accurately regulated by a screw acting against a spiral spring. At the same time, water, or reagents, can be added, if desired, without raising the cover. When properly and well made, this compressor works exceedingly well, and I have had it in constant use for years, but some makers, unfortunately, have introduced variations and so-called "improvements" which just take away some of the essential and useful points. The semi-circular thin cover-glass must be cemented to the underside of the brass ring with a little gold size, so as to be quite firm and rigid, otherwise its action becomes uncertain, and very small objects cannot be held fast, or else are suddenly crushed.

Some more simple apparatus and devices may be mentioned for cases where no live box or compressor is at hand. An excavated glass slide makes a fair live cage; a drop of water containing the animals is placed in the cavity so as to just fill it and no more; another drop of clean water is placed by the side of the cavity, and a clean thin cover-glass is lowered on to that second drop; then, by means of a needle, the cover is slowly pushed across the cavity, which can thus be covered without enclosing an air bubble; the superfluous water is taken up by blotting paper, the cover-glass being held in position by capillary attraction. This forms a good slide for low and medium powers, but not for high powers. Another good temporary slide can be made by placing three small fragments of No 1 thin cover-glass near the middle of a glass slip in form of a triangle; the drop of water containing the animals is placed in the centre, and a clean thin cover-glass is lowered on to the drop so as to rest on the three glass fragments, which prevent the animals getting crushed. If there be too much water it can be removed with blotting paper. Low and high powers can be used on this slide as far as the movements of the animals will permit, but not oil-immersion lenses.

Having thus mentioned some essential and necessary apparatus, I will close with a few remarks on the examination of living Pond-life. The free-swimming organisms, including such forms as *Volvox globator*, collect on the light side of the window aquarium, and can there be picked up in small or large numbers, and quite clean, with the large pipette, and placed in the trough; or any particular species can be selected with the aid of the tank microscope, and taken up with the smaller pipette, and transferred to the live box or compressor in a single drop of clean water, both hands being free for this operation.

The fixed forms, such as Polyzoa, *Stephanoceros*, *Melicerta*, *Floscules*, etc., amongst Rotifers, and *Stentor*, *Carchesium*, *Zoothamnium*, etc., amongst Infusoria, require a little management. If simply placed in a trough, these are often obscured, or incapable of being properly illuminated, by being too crowded, or by part of the weed over or underlying the objects, and also by floating particles in the water. The best result is obtained by trimming, that is by cutting off a very small piece of weed or leaf on which the animal is attached—in a watch glass under the dissecting microscope if necessary—and then transferring it with the pipette to the compressor into a drop of clean water; it can there be arranged with a needle or bristle as may be desired, and after lowering the cover-glass, fixed and held fast, at the same time giving the animal perfect freedom to expand. In this position the animals can be reached with the achromatic condenser from below for transmitted light and dark ground illumination, and also with low and high powers, and even oil-immersion objectives from above.

For Pond-life work the Wenham binocular is decidedly to be preferred to the monocular microscope. It is less tiring to the eyes to look with both eyes, and without strain, and the stereoscopic image gives a very much better idea of the true shape of the animals, though the images are not quite so sharp as with the monocular tube; but this binocular form can immediately be changed into a monocular for high power work, or whenever desired by pushing the small prism out of the way.

The binocular is to be used only with the low powers up to the $\frac{2}{3}$rd inch objective; with higher powers the stereoscopic effect is lost, because the depth of focus, or the plane of distinct vision, is then exceedingly small, and becomes more and more a mere optical section of the object.

A mechanical stage is hardly necessary; for ordinary work, a well-made sliding stage or bar is preferable, and should be provided. Stage clips, of which opticians are so fond, are abominations, and should be consigned to the dust-bin.

Of illuminating apparatus, the Abbé form of substage condenser, achromatic if possible, is the only one that is really useful for all powers, and that need be considered both for transmitted light and for dark ground illumination. It should be provided with an iris diaphragm and an arm carrying a central stop, and then completely replaces all the older substage apparatus—condenser, spot lens, paraboloid, etc. The bull's-eye stand condenser, however, is necessary to render parallel the rays of the lamp flame, but it should be mounted on the lamp, and move about with the lamp, and so as to project an enlarged image of the edge of the flame on to the flat mirror of the microscope for dark ground illumination with low powers.

All apparatus used in the examination of Pond-life—troughs, live boxes, compressors, and pipettes—should always be carefully cleaned and dried immediately after use, and in no case should the water be allowed to evaporate in them. Much trouble will be saved by the observation of this rule, and the apparatus will always be ready for use.

"ULTRA-MICROSCOPICAL" PARTICLES.

The meeting of the Royal Microscopical Society, held on the 17th June last, proved to be the most interesting and successful of the session. It had been anticipated that Lord Rayleigh would have been present to read his paper on "The Theory of Microscopic Vision," but he was unfortunately unable to attend, and the paper was read by Dr. Hebb. The great feature of the evening then became a paper by Dr. H. Siedentopf, a member of the scientific staff of the Jena Glass Works, dealing with the visibility of ultra-microscopical particles, illustrated by several objects arranged in the manner prescribed by him, and demonstrating the subject in a very wonderful manner.

It has of course long been known that whilst there is a fairly well-defined limit of resolving power—in other words, a *minimum distance apart* beyond which two or more particles or elements of structure cannot be *seen* apart—there is no such limit for the size of the separate particles themselves, at any rate not when they are placed in a strong light against a dark background; for under these conditions the smallness of the reflecting surface of the particles can be compensated for by the brightness of the illumination, in much the same way as minute particles of floating dust become visible in the path of a ray of sunlight through an otherwise shaded room.

The interesting and novel parts of Dr. Siedentopf's paper were those dealing with the methods adapted for carrying this system of rendering minute particles visible, to its utmost limit, and those which resulted in fairly reliable estimates of the actual size of the particles.

The usual dark-ground illumination is not very efficient, for whilst it is easy enough to find a stop which will not allow a single ray of regularly refracted direct light to pass through the microscope, it is impossible to prevent a quantity of scattered light produced by reflection from the mounts of condenser and objective, and by double reflections at the numerous lens surfaces, from reaching the eye and rendering it less sensitive to feeble impressions.

This difficulty Dr. Siedentopf overcame in a most ingenious manner by taking advantage of total reflection. He arranged his condenser (a dry one) at right angles to the optical axis of the microscope, so that its concentrated light entered the slide containing or forming the object, laterally. It will at once be seen that none of this light can emerge into air through the upper surface of the slide, as this would demand a refractive index of 1·414,—lower even than that of fluorite. The light diffused by small particles is therefore the *only* light that reaches the eye, and the latter will therefore be sensitive to its utmost limit.

But it is further necessary to limit the illumination to particles within the limits of depth of focus, as otherwise the light scattered by particles not in focus would form a luminous background; this object Dr. Siedentopf attained by focussing the source of light—generally the electric arc—on an adjustable spectroscope-slit, then focussing the slit in his object.

By the use of this refined method, Dr. Siedentopf was able to prove by direct observation that the beautiful red glass, known as gold-ruby glass, contains small detached particles of gold of extremely small size. By computing the cubic space under observation, counting the particles within that space, and ascertaining by analysis the percentage of gold in the glass under examination, it was found that the particles were equal in weight to tiny cubes of gold having sides equal to from one-sixth to five one-millionths of an inch. Though almost inconceivably minute, the particles are still composed of a great number (at least 10,000, according to Dr. Siedentopf) of molecules. These latter must, therefore, still be considered as invisible.

Very minute particles of other origin were also demonstrated, for instance the flagellæ of certain bacteria, and we may confidently look forward to important additions to our knowledge resulting from an intelligent application of the methods of illumination and of observation devised by Dr. Siedentopf.

One interesting question was not, as far as we are aware, gone into by Dr. Siedentopf, viz., why the gold-ruby glass should transmit chiefly red light; this seems rather puzzling, for thin layers of metallic gold transmit green light. Could the colour arise in a similar manner to the blue of the sky?

RUDIMENTS OF PALPI IN DIPTERA.—It is not generally known that the palpi present on the proboscis of our common house flies, *Musca domestica*, and *Homalomyia canicularis*, are labial, that is to say, attached to the lower lip. The exceedingly minute remains of the maxillary palpi can be made out on the anterior ends of the levers that work the lancet. These parts are embedded in the proboscis, but if a preparation is mounted under pressure, after having had the soft parts cleared away by caustic potash, the levers can be seen through the transparent membrane, and a good "sixth," with careful substage illumination, will show some hairs on the tubercles at the anterior ends. These parts are the stipites and cardines of the inner jaws (maxillæ.) A series of palpi can be seen in different species, from a well-developed hairy organ, protruded through the membrane, to a small embedded bulb, which has lost the few hairs we see in *M. domestica*. This, regarded from the evolutionary point of view, is exceedingly interesting.

Communications and enquiries on Microscopical matters are cordially invited, and should be addressed to M. I. CROSS, KNOWLEDGE *Office*, 326, *High Holborn, W.C.*

NOTES ON COMETS AND METEORS.

By W. F. DENNING, F.R.A.S.

NEW COMET.—A pretty bright comet, with nucleus and tail, was discovered by Borrelly, at Marseilles, just before midnight on June 21, in R.A. 21h. 52m. 52s., Dec. S. 8° 10′. The direction of motion was towards N.N.W. On June 30, at 0h. 30m. a.m., the writer, at Bristol, observed the comet, and found it distinctly visible to the naked eye. It had a bright nucleus, and a tail of about ¼ degree flowing to the S.S.W. The comet will be in perihelion at the end of August, and during that month will move from Ursa Major, through Leo Minor into Leo.

Alphonse Borrelly, the fortunate discoverer of this object, achieved distinction as a comet finder a generation ago. He sighted his first comet on 1871, October 12, and found five others during the six ensuing years. With a single exception, all the comets seen during the ten years, from 1868 to 1877 inclusive, were discovered by one or other of the famous comet seekers, Borrelly, Coggia, Tempel and Winnecke.

BROOKS'S PERIODICAL COMET (1889 V.–1896 VI.).—This comet will reach its nearest point to the earth on about August 17, though it will not pass through perihelion until the second week in December. The comet is rather unfavourably situated for northern observers, as it is 27 degrees south of the equator, but it ought to be pretty well seen from stations having a very open, unobstructed view southwards. It is moving very slowly westwards, its place at the end of August being only 5 degrees west from that occupied at the opening of the month. The following is an ephemeris for Berlin midnight:—

1903.		R.A. H.	M.	S.		Declination. °	′
August 11	...	21	8	20	...	26	59
„ 15	...	21	5	7	...	27	3
„ 19	...	21	2	0	...	27	6
„ 23	...	20	59	4	...	27	5
„ 27	...	20	56	25	...	27	1
„ 31	...	20	54	7	...	26	53

During this period the comet's distance from the earth will be about 110 millions of miles.

DOUBLY-OBSERVED METEORS.—The real paths of an interesting pair of bright meteors recorded at the April epoch have been computed by Mr. W. E. Besley and by the writer, and the results, placed side by side for comparison, are as under:—

		April 22, 10h. 23m. W. E. B.	W. F. D.		April 22, 12h. 32½m. W. E. B.	W. F. D.
Height at appearance	...	42½m.	45m.	...	75m.	78m.
Height at disappearance	...	26m.	26m.	...	41m.	43m.
Length of path	...	17m.	20m.	...	44m.	49m.
Velocity per second	...	5½m.	6½m.	...	35m.	39m.
Radiant point	...	151° + 47½°	150° + 49°	..	270° + 32°	269° + 32°
Name of meteor	...	Ursid.		...	Lyrid.	
Observers	...	C. L. Brook, Meltham. A. King, Leicester.		...	A. S. Herschel, Slough. A. King, Leicester.	

There was also a fine Lyrid observed on April 22, 10h. 36m., by Prof. Herschel at Slough, and Mr. T. H. Astbury at Wallingford. The heights were from 70 to 56 miles over Northamptonshire.

FIREBALL.—Mr. F. L. Raymond writes from Yeovil that on June 30, 8h. 50m., he observed a magnificent meteor. It was white at first, then orange, and moved rather slowly from due S. to a point about 5 degrees above S.E. horizon. The meteor left a short diffused trail, but the exact path was difficult to locate owing to the very strong twilight. The same object was seen by the Rev. S. J. Johnson, of Bridport, who gives the time as 8h. 52m., and says the path was from an altitude of about 15 degrees in due south to about 5 degrees above horizon at a point a little to the eastward. Motion rather slow; duration 3 seconds. Miss Mary E. Glennie also writes from Dinan, France, that the fireball as seen from that place appeared larger than the moon, and emitted zigzag streams of fire as it went along. A sound like distant thunder was heard about a minute after its disappearance. At St. Brieux, France, the bolide passed from W. to E.,

at no great distance above the horizon. At Dawlish, on the Devon coast, the aspect of the meteor was described as splendid, and as appearing under the form of a fiery bolt dropping into the sea.

THE GREAT PERSEID STREAM.—The maximum of this shower will probably occur on the morning of August 13 this year, and observations should be obtained during the nights of the 10th to 14th, if clear, with a view to fixing the hour of greatest abundance. Observers of the display should carefully record the flights of non-Perseids as well as the most brilliant Perseids. But it is scarcely desirable to preserve details of the fainter members of this system, myriads of which have been already recorded during its previous returns.

THE FACE OF THE SKY FOR AUGUST.

By W. SHACKLETON, F.R.A.S.

THE SUN.—On the 1st the sun rises at 4.24 and sets at 7.48; on the 31st he rises at 5.10 and sets at 6.50.

Sunspots and faculæ may now be observed almost any day; at the time of writing there is a fairly large spot near the central meridian.

THE MOON:—

	Phases.	H. M.
Aug. 8	○ Full Moon	8 54 A.M.
„ 16	☾ Last Quarter	5 22 A.M.
„ 22	● New Moon	7 51 P.M.
„ 29	☽ First Quarter	8 34 P.M.

The moon is in apogee on the 6th, and in perigee on the 21st.

There are no occultations of the brighter stars observable at convenient hours.

THE PLANETS.—Mercury is an evening star in Leo, but is not well placed for observation, as he sets too soon after the sun.

Venus is now very bright, but does not set so late as during the past few months. The planet is at *greatest brilliancy* on the 12th, when the earth is receiving the maximum amount of light from the disc, this point as determined by the celebrated problem of Halley's is when the elongation of the planet is about 40°, the diameter of Venus about 39″, and the enlightened part about 10″. The planet, therefore, at this time appears a little more than a quarter illuminated, and corresponds to the moon when five days old. The point of maximum brilliancy takes place about 36 days before inferior conjunction, hence the planet rapidly approaches the sun towards the end of the month, setting on the 31st about 6.55 P.M. Venus can readily be picked up during the day with a pair of field-glasses, and near the time of greatest brilliancy, having thus once found it, it can frequently be seen with the naked eye. On the 12th the planet is on the meridian at 2.26 P.M., and has an altitude of 36°.

Mars is still observable throughout the month soon after sunset; he is, however, by no means the conspicuous object that he was. Near the beginning of the month he is not far from Spica Virginis, but moves easterly into Libra towards the end of the month. The lustre of the planet is rapidly decreasing, as the apparent diameter is only 6″·6 on the 15th, 0·88 of his disc being illuminated.

Jupiter is again rising sufficiently early that observations may be made before midnight. On the 1st he rises about 9.20 P.M., and on the 31st at 7.15 P.M. Near the middle of the month he is on the meridian at 2 A.M., when the apparent polar and equatorial diameters are 46″ and 49″ respectively.

The most interesting satellite phenomena visible before midnight are as follow:—

Date.	Satellite.	Phenomenon.	Time. P.M.	Date.	Satellite.	Phenomenon.	Time. P.M.
Aug.			h. m.	Aug.			h. m.
2	III.	Tr. E.	11 5	18	II.	Tr. E.	9 6
8	I.	Ec. D.	10 36	23	I.	Sh. I.	11 36
9	I.	Sh. E.	10 6	24	I.	Ec. D.	8 54
„	I.	Tr E.	10 55	„	I.	Oc. R.	11 38
„	III.	Sh. E.	11 24	25	II.	Tr. I.	8 43
„	III.	Tr. I.	11 27	„	I.	Tr. E.	8 49
16	I.	Sh. I.	9 42	„	II.	Sh. E.	10 30
„	I.	Tr. I.	10 22	„	II.	Tr. E.	11 23
„	II.	Ec. D.	10 27	27	III.	Oc. R.	10 55
„	I.	Sh. E.	12 0	31	I.	Ec. D.	10 49
17	I.	Oc. R.	9 53				

Ec. = Eclipse. Tr. = Transit. Oc. = Occultation. Sh. = Shadow. E. = Egress. I. = Ingress. D. = Disappears. R. = Reappears.

Saturn is rather low down in Capricornus. On the 1st he rises about 7.40 P.M., and on the 31st at about 5.30 before sunset. Near the middle of the month he souths at 11 P.M.; his polar diameter is 17″·2.

The northern surface of the ring is visible and the ring plane is inclined to our line of vision at an angle of 19°. The diameter of the outer major and minor axes are 43″ and 14″·3 respectively.

Uranus is low down in Ophiuchus, not far from θ and 44 Ophiuchi (the chart given in the June number enables the planet to be found readily); the disc can be made out with a power of about 100, the diameter being 3″·9. On the 1st the planet is on the meridian at 8.48 P.M., and on the 31st at 6.48 P.M., setting on these dates at about 12.45 A.M. and 10.45 P.M.

Neptune is a morning star, and not observable at convenient hours.

THE STARS.—About 9 P.M. at the beginning of the month the constellations to be noticed are:—

ZENITH . Lyra (*Vega*), Hercules, Draco.
SOUTH . Sagittarius, Scorpio, Ophiuchus, Aquila; Aquarius and Capricornus to the S.E.
WEST . Boötis, Corona; Great Bear to the N.W., Virgo and Libra, S.W.
EAST . Cygnus, Delphinus, Pegasus, Aries; Andromeda and Cassiopeia to the N.E.
NORTH . Ursa Minor, Auriga (*Capella* on horizon).

Minima of Algol occur on the 13th at 10.55 P.M., and on the 16th at 7.43 P.M.

Chess Column.

By C. D. LOCOCK, B.A.

Communications for this column should be addressed to C. D. LOCOCK, Netherfield, Camberley, and be posted by the 10th of each month.

Solutions of July Problems (P. G. L. F.).

No. 1.

1. Kt to B3, and mates next move.

No. 2.

Key-move—1. Q to K3.

If 1. . . . P to B4, 2. Q to K7ch.
1. . . . P to R5ch, 2. R × RP dis. ch.
1. . . . P to R6, 2. R to B5 double ch.
1. . . . P to Kt6, 2. R × RP dis. ch.

SOLUTIONS received from "Alpha," 2, 4; W. Nash, 2, 4; G. A. Forde (Major), 2, 4; G. W. Middleton, 2, 4; "Quidam," 2, 4; J. W. Dixon, 2, 4; C. Johnston, 2, 4; H. F. Culmer, 2, 4; T. Dale, 2, 4; E. A. Servante, 2, 4; "Looker-on," 2, 4; W. H. S. M., 2, 4.

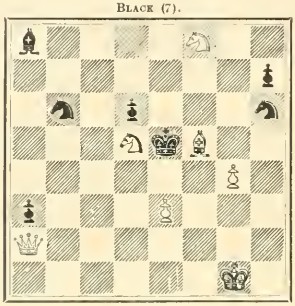
"*Quidam.*"—I cannot find that you were credited with any points for solutions of the May problems, and much fear that your solutions must have gone astray in the post. I have no record of them in my score-book, nor are they mentioned in the proof-slips of the June number which I have by me. But if, as you say, they were acknowledged as correct in that number, you will of course be credited with them. I regret that I am unable to verify this till next week.

W. Nash.—I am afraid I have no idea. Probably the publishers of Knowledge could give you the information you require.

PROBLEMS.

No. 1.
By W. Geary.

Black (7).

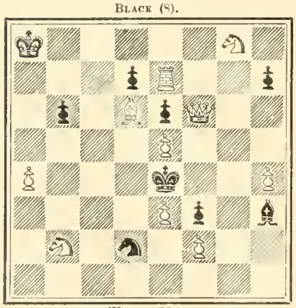


White (7).

White mates in two moves.

No. 2.
By A. Lillie.

Black (8).



White (11).

White mates in three moves.

The score of the following game is taken from *Brighton Society*:—

"Queen's Pawn" Opening.

White.	Black.
C. Schlechter.	Dr. Tarrasch.
1. P to Q4	1. Kt to KB3
2. P to QB4	2. P to Q3
3. Kt to QB3	3. QKt to Q2
4. P to K4	4. P to K4
5. Kt to B3	5. B to K2
6. B to Q3	6. Castles
7. Castles	7. P to B3
8. P to KR3	8. Q to B2
9. B to K3	9. R to Ksq
10. Kt to KR4	10. Kt to Bsq
11. Kt to B5	11. B takes Kt
12. P takes B	12. QR to Qsq
13. P to Q5	13. P to QR3
14. R to Bsq	14. Kt (Bsq) to Q2
15. P to KKt4	15. Kt to B4
16. B to Ktsq	16. P to QR4
17. K to Rsq	17. Kt (B3) to Q2
18. P to Kt5	18. P to B3
19. P to KR4	19. B to Bsq
20. R to Ktsq	20. B to K2
21. Q to R5	21. Kt to Bsq
22. R to Kt3	22. R to Rsq
23. B takes Kt	23. P takes B
24. P to Q6	24. Q takes P
25. Kt to K4	25. Q to Qsq
26. R to Qsq	Resigns.

CHESS INTELLIGENCE.

The death is announced of Mr. C. J. Newman, a well-known American player, who has taken part in the last five cable matches against Great Britain. On his first appearance in these encounters he saved most ingeniously what appeared to be a hopeless game.

The first-class Open Tourney of the Kent County Association was won by Mr. G. Shories, of Brighton, with a score of 7 out of a possible 8. The other leading scores were—G. A. Thomas, 5; E. Cresswell and R. Loman, 4½; J. Mortimer, 4.

The Southern Counties' Chess Union holds its annual meeting at Plymouth this year, from August 31st to September 9th. The winner will hold the Amateur Champion Cup, at present in the custody of Mr. R. P. Michell. Intending competitors should address Mr. W. P. Weekes, 7, Sussex Terrace, Plymouth.

Mr. F. J. Marshall has caused some sensation by challenging Dr. Lasker for the championship of the world. It is thought probable that the offer will be declined, on the ground that Mr. Marshall has not yet met with sufficient success to justify the issuing of such a challenge.

All manuscripts should be addressed to the Editors of Knowledge, 326, High Holborn, London; they should be easily legible or typewritten. All diagrams or drawings intended for reproduction, should be made in a good black medium on white card. While happy to consider unsolicited contributions, which should be accompanied by a stamped and addressed envelope, the Editors cannot be responsible for the loss of any MS. submitted, or for delay in its return, although every care will be taken of those sent.

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For Contents of the Last Two Numbers of "Knowledge," see Advertisement pages.

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CONTENTS.

FAMILIAR BRITISH WILD FLOWERS AND THEIR ALLIES.

By R. LLOYD PRAEGER, B.A.

V.—HEATHS AND GENTIANS.

HEATHS and Gentians! What pleasant pictures do the names bring before the mind. Beautiful plants, with graceful forms and brilliant flowers. Summer days amid the hot bee-filled heather. Wide brown moors, or alpine flower-starred pastures. In point of fact, the plants constituting these groups are, like the Saxifrages, redolent of the wild open country; of rock, and sand-dune, and mountain solitude. The fertile plains yield but a scant few of them; about the murky town we seek in vain a single one. And at this season of the year, when many of us are away in the home of the Heaths and Gentians, or have still fresh memories of the mountain breeze, and the fragrance of the Heather, we may appropriately spend a little while in a study of plants which give us so much pleasure.

The Heath family, or *Ericaceæ*, forms an assemblage of shrubs—or occasionally herbs—which have a wide distribution over the globe. They are generally found in rocky or boggy places in temperate countries, and especially frequent sub-alpine regions. The Cape of Good Hope is the home of an immense number of species of the typical and largest genus of the Order *Erica*. This genus yields the numerous lovely Heaths that are found in cultivation, and which must be ranked among the most beautiful plants which our greenhouses can boast. The plants of this Order have, as their most remarkable character, their beauty. Only a few possess medicinal or other properties. In the whole vast genus *Erica* there is not a single instance of a medicinal species. A few members of allied genera, including the familiar Ling (*Calluna vulgaris*), and the Bearberry (*Arctostaphylos Uva-ursi*), are astringent. Some of the Rhododendrons and Azaleas are strongly narcotic. The berries of some succulent-fruited species, such as the Cranberry, are used as food, but the list of economic virtues in the Order is very short. But from the point of view of aesthetics, what a gold mine the *Ericaceæ* furnish. Not only the myriad many-tinted Heaths, but the glorious Rhododendrons and Azaleas belong here; also the Kalmias, Andromedas, Ledums, and Arbutus. The species, as a whole, show a decided preference for peaty soils, and many of them cannot endure lime, which renders difficult the cultivation of the larger sorts, such as Rhododendrons, in certain districts.

Leaving the gorgeous Himalayan Rhododendrons and Cape Heaths, we must turn to the British representatives of the Order, which, if modest in comparison with these glorious plants, are nevertheless full of beauty and interest. The British *Ericaceæ*, taking the term in a wide sense, may be divided into five tribes: *Arbuteæ*, characterized by a succulent superior fruit, and represented by the Strawberry-tree and Bearberry; *Ericeæ*, including the Heaths and their immediate allies, all small shrubs; *Vaccinieæ*, with a fleshy inferior fruit, represented by the Whortleberry and its relations; *Pyroleæ*, containing the beautiful Wintergreen; and *Monotropeæ*, consisting of strange white or brown leafless herbs, of parasitic or saprophytic habits.

The Strawberry-tree, *Arbutus Unedo*, is the largest of the British *Ericaceæ*, forming a small bushy tree which may attain a height of twenty feet. Its evergreen foliage, clusters of winter-borne Lily-of-the-Valley-like flowers, and pretty, rough, scarlet fruit, make it a favourite in shrubberies. As a native, it grows only in a small portion of the south-west of Ireland. Around the shores and on the islands of the Upper Lake of Killarney it may be seen at its best, contributing very materially to the arboreal vegetation of that delightful spot. Abroad, it occurs across the Spanish peninsula, and all along the Mediterranean. The Bearberries (*Arctostaphylos*) are small evergreen shrubs, with pretty *Arbutus*-like flowers and shining berries. *A. alpina*, which has bluish-black berries, is a rare Scottish alpine. *A. Uva-ursi* is more widely spread, and though generally alpine in its distribution, in the west of Ireland it descends in sheets to sea-level. It has far-stretching, trailing, branching stems, pink flowers, and bright red berries.

We come now to the *Ericeæ*, or true Heaths. Of the six British Genera—*Andromeda*, *Calluna*, *Erica*, *Azalea* (= *Loiseleuria*), *Phyllodoce* (= *Bryanthus*), and *Dabeocia* (= *Boretta*), all but the third (*Erica*) have only a single representative. All are small evergreen shrubs, affecting peaty soils. The Marsh Andromeda (*A. Polifolia*) is a plant of peat bogs, with the leathery recurved leaves, dark green above and white beneath, which so many of the Heath allies possess, and pink urn-shaped blossoms, which

are produced in early spring. The Ling (*Calluna vulgaris*) is familiar to every one. It is the most abundant social plant in the British flora. Over mile upon mile of mountain and moor it dominates the vegetation, and is equally

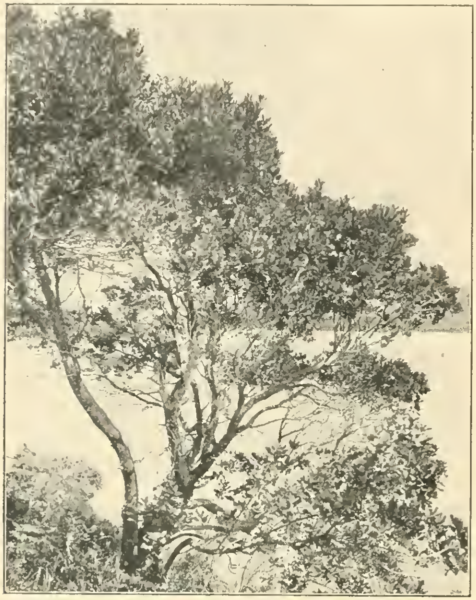


FIG. 1.—The Strawberry-Tree on a Kerry lake-shore.
[R. WELCH, Photo.

at home on southern sand-dunes and on Scottish mountain-tops. Examine the flower carefully. The calyx is conspicuous and coloured, deeply cleft into four lobes; the corolla quite insignificant in comparison, bell-shaped, and much shorter than the calyx. Note also the tiny leaves, arranged in four close rows. The genus *Calluna* possesses only this one species; but it makes up in number of individuals what it lacks in variety. The Ling is spread all round the Northern Hemisphere, and where it occurs it usually forms a conspicuous feature of the vegetation.

The Heaths proper (*Erica*) number six British species. Two of these, the common purple Heather (*E. cinerea*) and the pink Bell-Heather (*E. Tetralix*) are familiar plants on every heath and mountain side. The other four are of very local and peculiar distribution. Two of them, the Mediterranean Heath (*E. mediterranea*) and Mackay's Heath (*E. Mackaii*) are confined to a definite area in the west of Ireland, in the counties of Galway and Mayo. The other two, the Cornish Heath (*E. vagans*) and the Fringed Heath (*E ciliaris*), grow only in a restricted area in the south-west of England, in Cornwall and Dorset. All four are elsewhere found only in western France and the Spanish peninsula. This group of four Heaths forms, indeed, the focus of that peculiar group of plants of the western edge of Europe—West Ireland, West England, and the Pyrenean region—whose remarkable range has given rise to so much speculation among naturalists, and to the postulating of a former extension and continuity of the edge of the Continent, which formed a land surface along which these and other plants—and many animals likewise—migrated freely on the old edge of the Atlantic (*see* KNOWLEDGE, December, 1901, pp. 284-5). Of the four rare Heaths mentioned, *E. Mackaii* is a small plant with a habit like *E. Tetralix* *E. ciliaris* is a taller handsome plant with bright flowers in unilateral racemes. *E. vagans* grows several feet high, forming compact bushes with stiff erect branches. The small flowers are borne in racemes near the ends of the branches. *E. mediterranea* is the largest British Heath, forming bushes which may attain five feet in height, with erect branches clothed with spreading leaves. The pink blossoms appear in early spring, and the plant is usually at its best by March. The remaining three genera, *Azalea*, *Phyllodoce*, and *Dabeocia*, each with a single species, are rare plants of restricted distribution. *Azalea procumbens* is the most frequent of the three—a tiny tufted shrub found on the summits of high Scottish mountains, with crowded dark green leaves and umbel-like clusters of pretty pink flowers. *Phyllodoce cærulea* is also alpine in habitat, growing only on the Sow of Athol in Perthshire. It is a low-creeping shrub, with crowded narrow leaves and large single egg-shaped purplish flowers. Lastly we have *Dabeocia polifolia*, the largest-

FIG. 2.—St. Dabeoc's Heath. Half natural size.

flowered of all the British Heaths, growing only in Galway and Mayo, and forming another of the peculiar Irish-Pyrenean plant-group which has been already referred to. It is a trailing shrub, with ovate leaves conspicuously white beneath. The stems end in racemes bearing beautiful drooping egg-shaped bells half an inch in length. Its abundance amid the bogs and mountains of Connemara is to the botanist one of the most striking features of that wild and fascinating country.

Before passing away from the Heaths and their allies, a word is desirable as to certain features of leaf and flower which they display. In the flowers, the stamens strike us at once as peculiar. Take the flower of the Bell-Heather (*E. Tetralix*) for example (Fig. 3). The pendulous egg-shaped blossom has a comparatively small opening. The

style, occupying the axis of the bell, terminates in a stigma lying right in the opening. Surrounding this, and a little shorter than the style, are the stamens. The anthers are

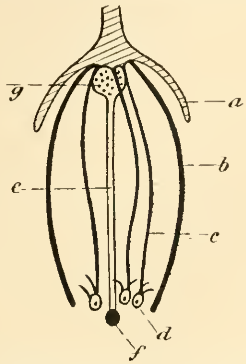


FIG. 3.—Diagrammatic Section of Flower of *Erica Tetralix*. *a*, Calyx; *b*, corolla; *c*, filament; *d*, anther; *e*, style; *f*, stigma; *g*, ovary. Enlarged.

roundish, and instead of splitting open, open by a pore at what, in the inverted position of the flower, is the lower end. Attached to each anther are two curious spreading horns. The stigma and the horned anthers almost block the entrance of the flower. Honey is secreted at the further end, near the ovary. The flowers are visited chiefly by bumble-bees. The bee, alighting on the bell, pushes its forehead against the stigma. At the same time its proboscis, pushed into the flower in search of honey, comes in contact with the spreading appendages of the anthers, and the disturbance causes pollen to drop out through the pore on the bee's forehead. Thus cross-fertilisation is effected. As to the leaves. That the leaves of many of these plants are curled backwards is a matter of common observation, but it is only on careful examination that we find how far this is carried in some of the species. While in the little Azalea (Fig. 4, 1) the leaf

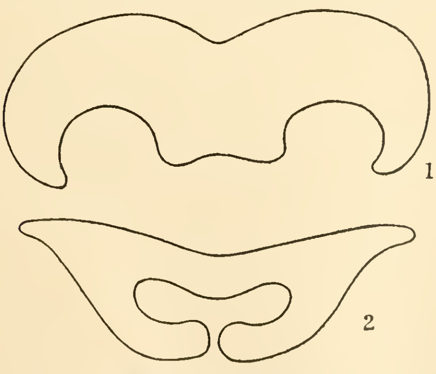


FIG. 4.—Outline sections of rolled leaves of *Ericaceæ*. 1, *Azalea*; 2, *Andromeda*. Enlarged.

is merely curved backwards, in others the curling is carried so far that a chamber is formed, the edges of the leaf almost meeting behind. The lower drawing on Fig. 4, which represents a foreign species of *Andromeda*, exemplifies this peculiarity. Similar chambered leaves are found in many plants—notably in grasses—and the object they serve is to prevent too rapid transpiration; the stomata, which are situated on the back of the leaves, being thus enclosed in a cool moist chamber. It may naturally excite surprise that the Heaths, which are in so large measure bog plants, growing in a soil reeking with water, should be thus protected from loss of water. The answer to this puzzle lies in a peculiar property of boggy soil, to which I have made reference in a previous article (KNOWLEDGE, September, 1902, p. 210). The water-logged soil is so badly aerated that soluble humus compounds remain in solution. Plants find difficulty in absorbing water charged with these substances, and hence they take precautions against undue waste of water. Such precautions we see in the small size of the leaves of the Heaths, and their rolled character.

To proceed with our review of the native *Ericaceæ*. The British *Vaccinieæ* comprise only the genus *Vaccinium*, which has four species. The familiar Whortleberry or Bilberry (*V. Myrtillus*) needs no description. Note the pretty pink urn-shaped flowers, produced almost before the leaves, and the curious spurs on the anthers—very characteristic of the Heath family. *V. uliginosum*, the Great Bilberry or Bog Whortleberry, is a small shrub with the general appearance of the last, found on mountains in Scotland and the North of England. *V. Vitis-Idæa*, the Cowberry or Red Whortleberry, has its home amid alpine rocks. It is a small shrub with creeping stems, producing upright shoots which bear shining evergreen leaves like those of Box, and pink flowers in which the corolla is more deeply cleft than in the before-mentioned species, being bell-shaped and five-pointed. The berries are red when ripe. The last species, the Cranberry (*V. oxycoccus*), is one of the most delightful of British plants—a tiny shrub, creeping among Sphagnum or short Heather, with long thread-like shoots, and short flowering stems which bear exquisite pink blossoms with four recurved petals. The leaves are recurved, glossy green above, white below; the berries large and red in colour. Altogether it is one of the daintiest plants which has a place in our flora.

The remaining *Ericaceæ* are plants of a quite different appearance from any of the preceding. The *Pyroleæ* are represented by four species of *Pyrola* and one of *Moneses*. The Pyrolas are pretty plants with a rosette of roundish root-leaves from which springs an upright stem bearing a graceful raceme of white or pinkish waxy flowers, with incurved petals and a remarkably long style. *P. rotundifolia* is a rare plant of bushy and reedy places; its flowers have a peculiar appearance owing to the drooping style, which protrudes from among the bundle of stamens. *P. media* and *P. minor* are of more frequent occurrence, in heathy places. They have a tolerably close resemblance, but may be distinguished by their straight style, which is much longer than the stamens and crowned with a ring in *P. media*, equal to the stamens and without a ring in *P. minor*. The fourth species, *P. secunda*, is montane in habitat, and distinguished, as its name implies, by the flowers on the raceme all facing in one direction (secund). The leaves, too, are oval, pointed, and serrate; instead of more or less orbicular and slightly crenate, as in the other species. The style is long and straight, with a large stigma. *Moneses grandiflora* is a rare north-Scottish wood plant, allied to *Pyrola*, but with large single white blossoms.

Lastly we have the *Monotropeæ*, represented in our country by the single species *Monotropa Hypopitys*—or *Hypopitys Monotropa*, if one prefers that. This curious flower has none of the characters which we associate with the Heath family. It is a pale yellowish plant, devoid of

leaves, and sending up fleshy scaly stems which bear a number of drooping flowers of the same hue. The Yellow Bird's-nest (as it is called, from its resemblance to the Bird's-nest Orchis) is a rare and rather southern plant in Britain, growing in thick woods, generally under Beech or Fir trees. Its whole appearance—the absence of leaves and of green colouring matter—suggest a parasitic or saprophytic habit. If we examine its curiously tangled root system, it will be found to be intimately associated with the mycelium, or webby underground portion, of a fungus; and the plant is always found in a soil rich in humus—in the leaf-mould that forms under thick trees. The plant feeds on the decaying vegetable matter, and apparently the process is rendered easier—or, perhaps, possible—by the presence of the fungus, whose thready stems are closely interwoven with the tissue of the root. The relations existing between the fungus and the *Monotropa*, with reference to the process of assimilation, however, have not yet been made clear.

The Gentian family is tolerably closely related to that of the Heaths, but it was association, rather than affinity, that suggested the bracketing of the two in the present sketch. Like the Heaths, this is one of those groups of plants whose presence makes one glad with the thought that towns are left far behind, and that sand-dune, moor, and mountain are around one. And while they differ from the Heaths in being all herbaceous, they rank worthily with them in attractiveness of form and colour. The two leading genera are *Gentiana* and *Erythræa*. The British Gentians have all blue or purplish flowers, the Centaurys all pink. Our native Gentians are five in number. The largest is *G. Pneumonanthe*, the so-called Calathian Violet, a plant confined to England, so far as the British Islands are concerned. Its stems are about a foot high, ending in large upright deep blue bells with five segments, each bearing a pale stripe. Next come our two commonest species, *G. Amarella* and *G. campestris*, small upright annuals, growing on dry heaths and pastures. In habit and leaf these two resemble each other, but they may be easily distinguished by the calyx, which has five equal segments in *G. Amarella*, four unequal segments in *G. campestris*. The corolla is likewise five-parted in the former, four-parted in the latter. Finally we have two small mountain species. *G. nivalis* is a tiny annual, with an upright stem and bright blue flower, found only on high mountains in Perth and Forfar. Lastly we have *G. verna*, the most beautiful of our Gentians. It is a little tufted perennial, which in spring sends up a profusion of almost stemless flowers of the most wonderful vivid blue colour. It is a plant of limestone rocks, in England confined to sub-alpine situations in the north, in Ireland occupying a large area of low-lying as well as upland limestone country chiefly around Galway Bay. Though so local, it is usually abundant where it occurs; and the Galway pastures in April, all painted with its blossoms, form a sight never to be forgotten.

Fig. 5.—Flower of (1) *Gentiana Amarella*, and (2) *G. campestris*. Natural size.

The Centaurys recall, in their dwarf upright growth and opposite pairs of leaves, the annual Gentians; but their bright pink flowers render them easily recognizable among all the summer vegetation. Several forms occur, to which some botanists assign specific rank, while others treat them as sub-species of our aggregate, *E. Centaureum*. It is needless to enter into the characters of these forms in this place. Allied to *Erythræa* is *Cicendia*, of which our only species, *C. filiformis*, is a very slender and almost insignificant upright annual like a tiny Centaury with four-parted yellow flowers. It grows on damp sandy ground in the south-west of England and of Ireland. The genus *Chlora* has likewise only one British species, the well-known Perfoliate Yellow-wort, *C. perfoliata*, an annual plant easily recognized by its upright almost unbranched stems, with opposite glaucous leaves joined at their base, and bright yellow flowers. The *perfoliate* character of the leaves is worth noting, as this is one of the few British plants displaying that feature.

Fig. 6.—Perfoliate leaves of the Yellow-wort. Half natural size.

The two remaining British *Gentianaceæ* are plants differing widely from any which we have considered; a difference to be chiefly accounted for, no doubt, as in the case of *Monotropa*, by the different walk of life which they have chosen. One is a marsh plant, the other a water plant. The Bog-bean (*Menyanthes trifoliata*) grows in wet bogs and on the edges of pools. It is fleshy in all its parts. The stems, as thick as one's finger, often creep for several yards. They bear leaves with three broad egg-shaped leaflets, and racemes of remarkably pretty flowers. These are pink or white, and the inner side of the petals is densely covered with curious thick white hairs, which give the flowers a most peculiar appearance, differing from that of any other British plant. The last plant of the Gentian family is *Limnanthemum peltatum*, a thorough aquatic, living in ponds and slow rivers. This plant has adopted the floating leaves which the Water-Lilies and other plants find serviceable, and it looks very like a miniature Water-Lily, with its round leaves and yellow blossoms rising from among them. The root-stock is far below, creeping in the mud, and sends up at intervals to the surface shoots bearing the foliage and flowers. This is rather rare as a British plant—at least as a native—occurring chiefly in the midland counties of England.

MODERN COSMOGONIES.

By Agnes M. Clerke.

IV.—TIDAL FRICTION AS AN AGENT IN COSMOGONY.

The effects of tidal friction are of almost infinite complexity. How it will act in each particular case cannot be predicted off-hand; it is a matter for detailed enquiry. Mutually countervailing influences have to be taken into account; nor is the balance easy to strike. How it inclines may indeed often depend upon qualities and relations of the bodies concerned which lie outside the range of what can be distinctly ascertained. All that can be hoped for, then, is to arrive at estimates neither misleading by their ostensible precision, nor yet so vague as to be wholly uninstructive, of the part played by tidal forces in moulding the history of connected globes.

The assumption that they attract one another as if the mass of each were collected at its centre, is one of those convenient fictions without which the advancing feet of science would be impeded by entangled thickets of illusory refinements and superfluous elaborations. The fiction would correspond with fact only if the globes were truly spherical, and they could be truly spherical only if

they were ideally rigid. Cosmic bodies, however, suns and planets alike, are actually plastic spheroids; they can, to be sure, be treated without sensible error as attractive points when their distances are very great relatively to their diameters; but upon a closer approach inequality of action supervenes. The component parts of the gravitating masses respond, each individually, and in a measure independently, to the graduated pulls exercised upon them, and tidal strains begin variously to take effect.

Their historical significance was in part divined by Kant. His penetration of so recondite a secret is truly astonishing. A struggling young pedagogue in a remote Prussian province, profoundly learned, though no more than half-skilled in technical acquirements, saw by intuition what escaped the acumen of all the great geometers of the eighteenth century, namely, that the moon turns one perpetual face towards the earth, because its primitive rotation was stopped by the friction of earth-raised tides. He perceived besides that a reciprocal action of the same kind must affect the earth, and will continue to affect it until the day coincides in length with the month. Nor did he fail to point out that, in a molten state of the globes, the process would advance with comparative rapidity. To one solitary thinker, then, it became apparent, already in 1754,* that oceanic tides are, in cosmogony, of negligible importance compared with bodily tides.

There is no substance in nature that will not change its shape through prolonged stress, and the more readily the nearer it approaches to the fluid condition. The measurable heaping-up of the waters on the earth's surface at the bidding of the moon is thus a differential effect. It serves to gauge the relative mobilities of the solid globe and of its liquid envelope. If the former did not yield at all to the pull so readily obeyed by the latter, the tides would in fact be greater than they actually are in the proportion of about three to two, the ratio indicating for the earth an effective rigidity at least equal to that of steel.† If there were no discrepancy in rigidity between the various parts of our terraqueous world there would be no perceptible tides. The ocean and the bed of the ocean would rise and fall together, and to the same extent. In the far past, however, there was no discrepancy. The viscous earth took, as a whole, the form momentarily impressed upon it by the unequal attractions of the sun and moon on its variously distant sections, with the upshot of bringing the year, month, and day into relations so familiar as to appear inevitable.

But tidal friction does not merely act as a check upon rotational speed. One element of motion in a system cannot be altered without some counter-change in the others. They are coupled up together like a train of geared wheels. From the principle of the conservation of moment of momentum, we know with certainty that a loss in one direction must be compensated by a gain in some other. Tidal friction had then reactive consequences. They were first adverted to by Julius Robert Mayer in 1848,‡ and were brought prominently into view in the series of investigations begun by Professor Darwin in 1879. The rotational momentum removed from the earth by the drag of a circulating wave of deformation must assuredly have reappeared in some other part of the system. It was restored, in fact, by the widening of the lunar orbit § Concomitantly with the slackening of the earth's axial rate, the moon retreated from its surface pulled forward by the tidal crest continually in advance of its position. This redressed the balance by increasing orbital momentum, while at the same time diminishing the moon's linear velocity. The importance of this secondary frictional effect in the history of the earth-moon system was the virtual discovery of Professor Darwin.

That system occupies a critical situation in the solar cortège. The planets interior to it have no satellites; the planets exterior to it (Neptune making probably only an apparent exception to the rule) have two or more. The earth alone is truly binary; and the moon is not only its solitary companion, but it is by far the largest companion-body, relatively to the mass of its primary, to be found within the precincts of the solar domain. These circumstances are certainly not disconnected one from the other, and they obviously depend upon a single cause. Solar tidal friction was here the determining factor. The apportionment of satellites to the various planets was, beyond doubt, to a great extent prescribed by the degrees of retarding power over their axial movement brought to bear through the agency of sun-raised tides in their still plastic bodies. Hence the disruptive rate of spinning needed for the separation of satellites was never attained by either Mercury or Venus; they remained moonless for all time, and exposed, through the cutting down of their rotational velocity, to uncompensated extremes of temperature. How the earth was to fare in both respects, long hung in the balance. Rightly to forecast its destiny would indeed have demanded no common perspicuity in an intelligent onlooker. Although the solar drag upon its rotation had no more than one-eleventh its power over that of Venus, it nevertheless sufficed during uncounted ages to hinder acceleration from reaching the pitch involving instability. Our embryonic planet had long ceased to be nebulous, and had in fact shrunk by cooling nearly to its present dimensions before the die was cast. Then, at last, the hurrying effects of contraction prevailed over slowing down by tidal friction, axial speed overbore equilibrium, and the spheroid divided. Now globes thus far advanced in condensation are apt to split less unequally than globes in a more primitive stage; and the moon, because late-born, was of large size. Its mass is $\frac{1}{81}$ that of the earth; the masses of Titan and Saturn are as 1 to 4600; while Jupiter's third and greatest satellite contains only $\frac{1}{11300}$ part of the matter englobed in the parent-body. Moreover, Professor Darwin has made it clear that the satellites of Jupiter and Saturn revolve now in orbits not widely remote from those at first pursued by them; the moon, on the contrary, having started on its career almost, if not quite, from grazing contact with its primary. Owing to these two exceptional circumstances—its considerable relative mass, and its close initial vicinity—the moon wielded over the earth tidal influence incomparably more powerful than that exerted by any of its compeers in the sun's realm. Within its bounds, accordingly, the lunar-terrestrial system offers an unique example of a pair of globes, the mechanical relations of which have been settled on their present basis by the predominating agency of bodily tides. It holds forth, too, the one case in which origin by fission was possible. Professor Darwin's communication to the Royal Society in 1879 occasioned a remarkable diversion of ideas. Saturn's Rings were at last perceived to be illustrative of only one among many feasible modes of cosmic growth. It became clear that a single cut-and-dried method would not answer all the infinitely varied purposes of creative design. Annulation might have served its turn, but there were alternatives. A fresh stand-point was virtually attained, and the wide prospect commanded by it begins

* "Sämmtliche Werke," Bd. VI., pp. 5-12, 1839.

† G. H. Darwin, "Ency. Brit.," art. *Tides.*

‡ "Dynamik des Himmels," p. 49.

§ Darwin, *Phil. Trans.*, Vol. CLXXII., p. 528.

already to spread out invitingly before the gaze of investigators.

But whether the moon emerged from the earth as a protuberance, or was abandoned by it as an equatorial-ring, it was revolving, when our theoretical acquaintance with it begins, in a period of not less than two, and not more than four hours, quite close to the earth's surface; while the nearly isochronous rotation of the earth was conducted with all but disruptive rapidity. The situation is so suggestive that it needs only a short and tolerably safe leap in the dark to reach the conclusion that the two globes had very recently been one. With their division, at an epoch estimated to have been at least fifty-four million years ago, the process began by which the moon was pushed back along a widening spiral course to its present position, the vanished rotational momentum of the earth cropping up again in the augmented orbital momentum of the moon. And the transformation is, at least in theory, still going on.

Tidal friction has further capabilities. The transference of momentum from one part of a system to another is only the most obvious among the crowd of its results. Scarcely an element of movement escapes its influence. It increases, as a rule, orbital eccentricity. The smallest initial deviation from circularity develops, through the inequality of accelerative action thence ensuing, into pronounced ovalness. That of the moon's path can in this way be accounted for. Moreover, its plane was, in all probability, shifted simultaneously, and under compulsion of the same power, from its original coincidence with the earth's equatorial plane to the level now occupied by it. The obliquity of the ecliptic, too, is partially explicable on the same principle. "The present motion of the two bodies" (to quote Professor Darwin's words) are "completely co-ordinated by the theory that tidal friction was the ruling power in their evolution." Holding this clue, we are enabled to trace them back to the start of their dual existence, and to follow the insensible modifications by which their state was moulded to its actual form.

In no other satellite-system is this possible. No moon besides our own possesses a stock of orbital momentum large enough to intimate for it an analogous history. The planetary attendants travel nearly in their original tracks; the fluid ripples raised by them on the surfaces of their primaries lacked power to displace them. Their own rotation, indeed, seems to have been completely destroyed. Destroyed, that is, relatively to the destroying body. There is a certainty that some, there is the strongest likelihood that all of the Jovian and Saturnian satellites turn unchangingly the same face inward. They rotate in the periods of their several revolutions, just as our moon does, and as a consequence of the same cause. Tidal friction, however, appears to have been otherwise of subordinate importance in shaping their dynamical relations.

The agency will not, then, serve in all cases for a *deus ex machinâ*. It is not indiscriminately efficacious. The modes of its action have, in each of the systems considered, to be delicately distinguished. The stage of development arrived at by the globes affected, their degree of viscosity, their comparative mass and bulk, their modes of motion, all avail profoundly, and it may be incalculably, to modify the outcome. The facility of error in estimates of the kind is illustrated by Professor Darwin's remark that the magnitude of the tide-raising force is only one factor of the product.* The other is relative movement. Now, in the case of the moon, the former continually augmented retrospectively, while the latter fell off. Tidal generative power varies inversely as the cube of the distance; in antique times, then, when the earth and moon revolved contiguously, the bodily distortions they mutually produced must have been on an extremely large scale. Yet, because of the near coincidence of the periods of the globes, they must have been almost inoperative for frictional purposes. The travelling of the piled-up matter over their surfaces was too slow to lend it much efficiency as a friction-brake. The insignificant waves raised by the sun were, we are led to believe, because of their swift relative motion, more influential at that early epoch in checking terrestrial rotation than the colossal, but nearly stationary, waves due to the moon.

Numerical calculations, where they are practicable, afford the only safe guide to this intricate field of enquiry. It does not suffice to show that tidal action would have been of the kind required—would have taken the right direction—for bringing about some apparently anomalous result. Proof must besides be forthcoming that the action would have been of adequate power. Plausible guesses on the subject may be entirely fallacious. The machine, even if properly constructed for the end in view, may work too feebly for its attainment. We are, for instance, assured that no difficulty connected with the sense of planetary rotation need impede acceptance of the theory of planetary origin from separated rings, since even if the embryo globes gyrated the wrong way at the outset, solar tidal friction would promptly have reduced them to conformity with the general current of movement. This is true in principle; but will it bear quantitative investigation? Many promising hypotheses have broken down under the weight of figures; whether this particular one is strong enough to survive their application remains to be seen. We are, indeed, sure of its validity as regards Mercury, but the efficacy of tidal friction decreases as the sixth power of increasing distance, and the actual rotation of Venus furnishes an enigma sufficiently perplexing to discourage scrutiny of its dimly discerned antecedent conditions. As regards the earth and the exterior planets, the question could only be answered with the help of information which is not forthcoming.

Prof. Darwin's researches were fruitful just because they were definite. They demonstrated, once for all, the power of tidal friction as a cosmogonic agency, and indicated clearly the departments of cosmogonic change in which its competence lay. They availed, moreover, to determine for the earth-moon system the amount of work actually done by tidal friction in these several departments, and to prove its large excess over the corresponding output in any other sub-system falling within the sphere of observation. This memorable result suggests that our terrestrial home may be singular, not only in its evolutionary history, but in the innumerable adjustments fitting it to be the abode of life.

The relations of the earth and moon adumbrate, and scarcely more than adumbrate, the physical influences mutually exerted upon each other by numerous twin-globes in stellar space. Tidal friction is of maximum power in systems formed of equal masses; and those of double stars are seldom widely disparate. Most, if not all of them, were, besides, primitively very near neighbours; so that their symmetry must have been marred by conspicuous tidal deformations. The results upon their development have been expounded in detail by Dr. See. One of the most remarkable is the high average eccentricity of their orbits. Visual binaries, with few exceptions, travel in considerably elongated ellipses, while spectroscopic binaries usually pursue sensibly circular paths. Dr. See's argument that their eccentricity was acquired during the process of separation, under the influence of tidal friction, is well-nigh irresistible. True, this line of explanation is

* *Phil. Trans.*, Vol. CLXXI., p. 876.

not wholly clear of obstacles and incongruities. Yet they may probably be described as of a complicating, rather than of a contradictory kind. The theory of tidal friction is not an universal solvent of the difficulties encountered in the study of double stars. That the mode of action it deals with had a contributory share towards regulating their mechanical arrangements may, nevertheless, be regarded as certain, while the energy, and perhaps even the manner of its operation, varied extensively from system to system. What precisely it effected in each lies beyond our reach to determine. For the data available regarding the viscosity, density, and axial movements of fledgeling star-pairs must always be too scanty and insecure to provide a basis for rigorous computations. The mystery of the fore-time can never be entirely dissipated. Enough if we can look at it through a glass which darkens, without distorting, the objects presented in its field of view.

STELLAR SATELLITES.

By J. E. Gore, F.R.A.S.

The term satellite is usually applied to the moons which revolve round the planets of the solar system, like our own moon and the moons of Jupiter and Saturn. But the term is also sometimes used with reference to the faint companions of bright stars. In most of the known binary, or revolving double stars, the component stars which form these stellar systems are usually of nearly equal brightness, or at least do not differ very much in relative brilliancy. These may be called pairs of suns, or "twin suns." There are, however, some notable exceptions to this rule. Among those binaries for which orbits have been computed the following are the most remarkable:—Procyon, magnitudes 0·5 and 13 (or $12\frac{1}{2}$ magnitudes difference in brightness); Sirius, magnitudes 1·62 and 10 (about $11\frac{1}{2}$ magnitudes difference); δ Cygni, 3 and 8; 99 Herculis, 6 and 11; 85 Pegasi, 6 and 10; and η Cassiopeiæ, 4 and 7·6. Of those double stars which are known to be binary, but in which the motion hitherto has not been sufficient to enable an orbit to be computed, the following may be mentioned:—θ Ursæ Majoris, 3 and 14; α Ursæ Majoris, 2 and 11; β Leporis, 3 and 11; ι Ursæ Majoris, 3 and 10; η Geminorum, 3 and 10; 34 Pegasi, 6 and 12; and 26 Draconis, $5\frac{1}{2}$ and 11.

According to an orbit computed by Dr. See, and a parallax of 0″·38 found by Sir David Gill, the mean distance of the companion of Sirius from the bright star is about 21 times the earth's distance from the sun, or a little more than the distance of Uranus from the sun. The mass of the system is 3·47 times the sun's mass, the bright star being 2·36 times, and the satellite 1·11 that of the sun. With the above distance I find that the satellite, as seen from Sirius, would shine with about the brightness of full moonlight. As the mass of the satellite is about the same as that of our sun, its inherent light must be very small. If the sun were placed at the same distance from the earth its light would still be more than 1300 times that of the full moon.

The bright star Procyon forms a very similar system to that of Sirius. A close companion was strongly suspected by Otto Struve in 1873, and this was discovered in November, 1896, by Schaeberle with the great 36-inch telescope of the Lick Observatory. It is about the 13th magnitude. Dr. See finds a period of about 40 years, or about the same as that found by Auwers in 1861, from a consideration of some irregularities in the proper motion of Procyon. Dr. See finds the mean distance to be 21 times the sun's distance from the earth, and the mass of the satellite equal to that of the sun, or the same as in the Sirian system. The proper motion of Procyon is about the same as that of Sirius—1·3 seconds of arc per annum—and its parallax about 0″·32, only slightly less. The similarity of the two systems of Sirius and Procyon, in almost every particular, is very curious. The spectrum of Procyon is, however, of the second or solar type, and its mass about double that of Sirius. As Sirius is considerably brighter than Procyon (about two magnitudes), we have here another proof that stars with the solar type of spectrum have a larger mass in proportion to their brilliancy than stars of the Sirian type, or, in other words, of two stars having the same mass, but one with a Sirian and the other with a solar spectrum, the Sirian star would be much brighter than the solar one.

The 6th magnitude star 85 Pegasi has a "satellite" of the 10th magnitude. It is a binary star, and Dr. See finds a period of 24 years, with a mean distance of 0″·89. Burnham finds 25·7 years, and 0″·78. The proper motion of the system is about 1″·3, and a small parallax of 0″·054 was found by Brunnow. From these data I find that the mean distance is about 15 times the earth's distance from the sun. The orbits referred to above give the mass of the system from 4 to 8 times the sun's mass. The satellite as seen from the primary star would shine as a small sun, so that it must be considered rather as a companion sun than a satellite. The accuracy of the small parallax is of course somewhat doubtful, but if nearly correct the large proper motion would indicate a velocity of about 70 miles a second.

In addition to the above there are some stars which have faint companions "or satellites," the measures of which do not *directly* show orbital motion, but which are known to be physically connected, from the fact that the bright star and its faint attendant have the same "common proper motion." In other words they are moving together through space with the same velocity and in the same direction, and are therefore most probably near enough to be linked together by the laws of gravitation. In such cases the "satellite" probably revolves round its primary, but owing to the great distance from its central sun, the period of revolution would be very long, and the angular motion would not be perceptible for many years at the great distance at which the system usually lies from the earth. Let us consider some of these stellar systems. From the apparently great apparent distance which separates these satellites from the primary star, they seem to be constituted on a much vaster scale than those binary stars in which the motion is so rapid that an orbit can be computed. We will consider those stars for which a measurable parallax has been found, and for which, therefore, the distance from the earth is approximately known.

The bright reddish star, Aldebaran, has a faint satellite of about the 11th magnitude, at a distance of about 117 seconds of arc, which was originally discovered by Sir William Herschel. In the year 1888, this faint star was found to be a close double star by the famous American astronomer Burnham, with the 36-inch telescope of the Lick Observatory. He also found a closer and fainter companion—about the 14th magnitude—while using the $18\frac{1}{2}$-inch telescope of the Chicago Observatory in the year 1877. The distance of this faint satellite from the bright star is about 31″. Measures in subsequent years have shown that the distant double companion is not moving with Aldebaran, which has a proper motion of about 0″·19 per annum, but, curious to say, Burnham's faint companion has, notwithstanding its comparatively great distance from Aldebaran, *exactly* the same proper motion as the bright star, and is therefore most probably

physically connected with it. The result of this is that Herschel's distant companion is being gradually left behind—at least for the present—while Burnham's companion is accompanying Aldebaran in its flight through space. A parallax of 0″·107 was recently found for Aldebaran at the Yale University Observatory, U.S.A. Assuming this parallax and the above proper motion, the velocity of Aldebaran at right angles to the line of sight comes out about five miles a second.* The double companion has a proper motion of its own in a slightly different direction, amounting to about half that of Aldebaran. As this proper motion, small as it is, is an unusually large one for so faint a star, it has been suggested by Prof. Barnard that possibly its apparent motion may be really due to orbital motion round Aldebaran. However this may be—and time alone can decide the question—there can be no doubt that Burnham's faint satellite is physically connected with Aldebaran, and that the double companion also forms a physical system of its own. These facts render Aldebaran and its companions an interesting object of study.

Assuming that the line joining Aldebaran and Burnham's faint companion is at right angles to the line of sight—an assumption which would give the *minimum* distance between them—I find that the distance of the satellite from Aldebaran is about 300 times the earth's distance from the sun. Placed at this great distance from its central sun (10 times the distance of Neptune from our sun), the period of revolution round Aldebaran would be very long, and it is not a matter for surprise that no relative motion has been detected in the 25 years which have elapsed since its discovery. It will probably be many years more before its motion round its brilliant primary will become perceptible. Were our own sun placed at the distance of Aldebaran, I find that it would be reduced in brightness to a star of about the 5th magnitude, or about 40 times fainter than Aldebaran appears to us. This indicates that Aldebaran is a more massive sun than ours, and by its greater attractive power it may be able to control the motion of its distant satellite. As light varies inversely as the square of the distance, if we know the distance of Aldebaran from the earth and the distance of the satellite from Aldebaran, we can easily compute the brightness of the satellite as seen from Aldebaran, or from some planet revolving close to the bright star. Making the necessary calculation, I find that the light of the satellite would be increased by 19 magnitudes, if seen at the distance of 300 times the sun's distance from the earth. Hence, as seen from Aldebaran, the satellite would shine as a star of −5 magnitude, that is 5 magnitudes, or 100 times brighter than a star of zero magnitude, like Arcturus, or somewhat brighter than Venus is seen by us at the time of her greatest brilliancy.

A somewhat similar case is that of Regulus (α Leonis). This bright star has a satellite of about $8\frac{1}{2}$ magnitude at a distance of about 177″. This was found to be double by Winlock, the companion being of the 13th magnitude and distant about 3″ from the $8\frac{1}{2}$ magnitude star. Burnham's measures show that this double companion is moving through space with Regulus, the common proper motion being 0″·267 per annum. A small parallax of 0″·022 was recently found for Regulus at the Yale Observatory. With these data I find that the distance of Regulus from the earth is 9,375,000 times the sun's distance from the earth, and the $8\frac{1}{2}$ mag. star is at a distance from Regulus of about 8000 times the same unit. From this it follows that the $8\frac{1}{2}$ mag. star, as seen from Regulus, would shine as a star of $-6\frac{1}{3}$ magnitude, or about 8 times brighter than Venus at her brightest. The 13 mag. star would appear as a star of −2 magnitude, or somewhat brighter than Sirius as seen by us. The combination of a star 8 times brighter than Venus with one as bright as Sirius, and about one degree apart, would form a fine spectacle in the sky of Regulus. Our sun placed at the distance of Regulus would, I find, shine as a star of about 8·3 magnitude, or about the same brightness as the satellite appears to us. The satellite is therefore probably as large as our own sun. The difference of about 7 magnitudes between Regulus and the sun at equal distances indicates that Regulus is over 600 times brighter than the sun. It must therefore be a very massive body, probably much larger than Sirius,* and may therefore be able to control the motions of a satellite even at the great distance of 8000 times the earth's distance from the sun. The parallax and proper motion of Regulus indicates that its velocity at right angles to the line of sight is about 36 miles a second.

The bright star Rigel (β Orionis) has a companion of the 8th magnitude at a distance of $9\frac{1}{2}$″, discovered by Sir William Herschel. This small star was found to be an exceedingly close double star by Burnham in 1871. The measures are not yet sufficient to enable an orbit to be computed, but Burnham thinks that the period may possibly be very short. The measures of the 8th magnitude companion with reference to Rigel do not yet indicate any well-defined motion, but as it has the same proper motion as Rigel it is certain that there is a physical connection between them. The proper motion is small—about 0″·018 per annum. According to Sir David Gill, the parallax of Rigel does not exceed the hundredth of a second, or 0″·01. Assuming this parallax, the distance of Rigel would be at least 20 million times the sun's distance from the earth, and considering its great apparent brilliancy (0·28 magnitude) it is probably a sun of enormous size. Placed at the distance indicated by the above parallax the sun would, I find, be reduced to a star of about the 10th magnitude. A parallax of 0″·01 would place the satellite at a distance from Rigel of 950 times the sun's distance from the earth. At this distance its magnitude as seen from Rigel would be about $-13\frac{1}{2}$, or somewhat brighter than our moon appears to us.

The $4\frac{1}{2}$ magnitude star o^2 (40) Eridani has a small companion of about the 9th magnitude, at a distance of about 82″. This satellite was found to be double by Sir William Herschel in 1783. It is a binary pair, and Burnham finds a period of about 180 years. It has the same large proper motion as the bright star, about 4″·1 per annum, and a parallax found by Hall of 0″·22. This gives a distance from the earth of 937,570 times the sun's distance, and a distance between the bright star and its binary companion of 372 times the distance of the earth from the sun. The measures of position show evident signs of orbital motion, but the period is probably very long, perhaps several thousand years. Placed at the distance of o^2 Eridani, the sun would, I find, be reduced to a star of about $3\frac{1}{2}$ magnitude, or about one magnitude ($2\frac{1}{2}$ times) brighter than the star. I find that the binary satellite seen from its primary would give the light of a star of about −8 magnitude, or, in other words, the light of a small moon. The parallax and proper motion indicate a velocity across the line of sight of about 54 miles a second.

It was suggested by Sir John Herschel with reference to the faint companion of ι Ursæ Majoris, that it might possibly shine by light reflected from the bright star, and

* The motion *in* the line of sight seems to be much greater.

* Regulus has a spectrum of the Sirian type.

PHOTOGRAPHS OF COMET *c* 1903 (BORELLY).

By ISAAC ROBERTS, D.Sc., F.R.S.

S.

Fig. 1.

P.

F.

Fig. 2.

N.

Fig. 3

Admiral Smyth remarked, with reference to the double star Struve 946, "the possibility of the *comes* being variable awakens considerations of peculiar interest; it having been surmised that certain small acolyte stars shine by reflected light."* But it may be easily shown that this is highly improbable, if not impossible. Let us take the system of Sirius. In this case the satellite—although very faint for its computed mass—certainly does not shine by reflected light from Sirius. This will appear from the following considerations which I have carefully worked out. Assuming for a moment that the satellite shines merely by reflected light, let us see what its brightness would be as seen from the earth. According to the computed orbit and parallax of Sirius—which are probably as reliable as those of any binary star hitherto computed—the mean distance of the satellite from the bright star is a little more than the distance of Uranus from the sun. Let us assume this distance. (A greater distance would strengthen my argument.) As the computed mass of the satellite is about the same as that of the sun, let us assume that it has the same diameter or 866,000 miles (a smaller diameter would of course strengthen my argument), and let us take the diameter of Uranus at 33,000 miles—which is very near the truth. Now assuming the same "albedo," or reflective power for Uranus and the satellite of Sirius (the albedo of Uranus is very high), we have the satellite, as seen from Sirius, shining with a greater brilliancy than Uranus as seen from the sun in the proportion of 866,000 squared to 33,000 squared, or as 688 to 1. This is on the assumption that Sirius and the sun are of equal brightness. But from the photometric measures of Sirius, and its known distance from the earth, I find that Sirius is at least 20 times brighter than our sun. We must, therefore, increase the above ratio 20 times to obtain the illumination of the satellite by the light of Sirius. This gives $688 \times 20 = 13{,}760$. That is, the satellite as seen from Sirius would be about 13,760 times brighter than Uranus as seen from the sun. This number corresponds to 10·3 stellar magnitudes. Now, taking the magnitude of Uranus, as seen from the sun, at 5·8 (which must be very near the truth), we have the brightness of the Sirian satellite, as seen from Sirius, equal to $5·8 - 10·3$, or $-4·5$ magnitude, that is, $4\frac{1}{2}$ magnitudes brighter than a star of zero magnitude, like Arcturus, or slightly brighter than Venus appears at her greatest brilliancy as seen from the earth. Now, the the simple problem is this: if a body shines with a stellar magnitude of $-4·5$ as seen at the distance of Uranus, what would be its magnitude if placed at the distance of Sirius? Taking the parallax of Sirius at $0''·38$, we have its distance from the earth equal to 542,800 times the sun's distance from the earth. Hence the light of a body at the distance of Uranus would, if removed to the distance of Sirius, be reduced in the proportion of the square of 542,800 to the square of 19, or as 816,244,900 to 1. This corresponds to 22·3 stellar magnitudes. Hence the magnitude of the satellite of Sirius, as seen from the earth—*if shining only by reflected light from Sirius*—would be $22·3 - 4·5$, or 17·8 magnitude, and it would therefore be quite invisible in the great 40-inch telescope of the Yerkes Observatory, even if seen on a dark sky, the smallest star visible in that telescope being about the 17th magnitude. As its actual brightness is about the 10th magnitude, it follows that it is about 1300 times brighter than if it shone merely by reflected light, and it is evident that it must have some inherent light of its own. I have shown in the beginning of this paper that the actual brightness of the satellite, *as seen from Sirius*, is equal to that of full moonlight on the earth. We should obtain a very similar result if we assumed that Sirius is very much brighter than 20 times the brightness of the sun. If we assume it to be 10 times brighter than this, or 200 times the sun's brightness—a very improbable supposition—we should still have the satellite reduced to about the 15th magnitude, and placed as it is so close to such a brilliant star as Sirius, it would probably still remain invisible in our largest telescopes. The assumption I have just made is, however, quite inadmissible, for if we increase the light of Sirius we must increase its distance also, and this would further diminish the computed light of the satellite. We may, therefore, dismiss the idea that the satellite of Sirius could possibly shine merely by reflected light from its primary. The same considerations will apply to the case of Procyon and its satellite, and with greater force, as the satellite of Procyon is about three magnitudes fainter than the Sirian satellite, and Procyon is a less luminous sun than "the monarch of the skies."

* *Bedford Catalogue*, p. 155.

PHOTOGRAPHS OF COMET *c* 1903 (BORELLY).

By Isaac Roberts, D.Sc., F.R.S.

The comet was discovered on the 21st of June by M. Borelly, at the Observatory of Marseilles, and the fact was immediately communicated to the *Central-Stelle* at Kiel, from which centre Prof. Kreutz distributed the information to all the principal observatories in Europe and in America. Ephemerides of the positions and orbit of the comet were quickly issued, by aid of which astronomers could follow its movements in the sky and make their observations upon it.

The three photographs annexed hereto were taken on the 24th and 26th July, when the comet was seven days past that part of its orbit where it was computed to attain the maximum brightness, namely, 14·6 times brighter than on the day of its discovery. On the 24th July, when the photograph, Fig. 1, was taken, the brightness had diminished to about 11·0 times, and on the 26th, when the photos Figs. 2 and 3 were taken, the brightness had further diminished to about 9·8 times, and the light will continue to decrease till the comet again will be invisible.

Figs. 1 and 3 on the plate were taken with the Cooke 5-inch lens, the exposures being (1) 45 minutes, (3) 60 minutes; scale about 122″ of arc to 1 millimètre; the length of the part shown of the tail is about six degrees, but if the plate had been larger the tail would have been shown to be considerably greater in length.

If we compare Fig. 1 with Fig. 3 it will be seen that the tail has undergone a remarkable change in outline, in structure, and in density, during the interval of two days, and that the gap of about one and a half degrees in length from the head had almost closed up, and the tail had assumed a more symmetrical form of straight streamers and of apparent nebulous matter, but they are too faint to be fully shown on the print.

Fig. 2. This photograph was taken with the 20-inch reflector simultaneously with No. 3; the scale in this case being about 43″ of arc to 1 millimètre. It shows more clearly the structure of the tail than can be seen with the 5-inch lens. The length of the tail is about $2\frac{1}{4}$ degrees, for the plate was too small to show more of it, but the structure is well seen, consisting of streamers and vacant spaces between them. Unfortunately the bad weather and moonlight nights have prevented more photographic evidence being obtained at Starfield of this interesting comet.

The nucleus was strongly stellar, but the surrounding *coma* did not indicate any structural details. If the threefold classification of comets should be reliable, the three

forms of tails that pertain to them would indicate the presence of hydrogen, hydro-carbon, and iron in this one, but spectroscopic evidence will be necessary to prove this suggestion.

CYCLES OF ECLIPSES.

By A. C. D. Crommelin.

The computation of the circumstances of eclipses is such a laborious operation that it is not surprising that a great amount of energy has been directed, both in ancient and modern times, to the search for cycles after which the eclipses would recur with some or all of their features reproduced. Were an exact cycle discovered, we should be able, after calculating or observing all the eclipses of a single cycle, to deduce the conditions of all past and future eclipses.

For a cycle to be perfect it would require to satisfy five conditions, which we shall denote by the letters A, B, C, D, E. It should be an exact multiple:

A. Of the *lunation* or period of 29·53058844 days between one new moon and the next.

B. Of the *draconitic month* or period of 27·21221993 days between successive passages of the moon through either of her nodes.

C. Of the *anomalistic month* or period of 27·55455173 days between successive passages of the moon through her perigee.

D. Of the *solar year* or period of 365¼ days. As this condition is not so important as A, B, C, it is an unnecessary refinement to distinguish between the three kinds of years—sidereal, tropical, and anomalistic.

E. Of the solar day of 24 hours.

It is to be noted that the periods in A, B, C, are subject to variations; the values given are their *average* lengths according to Newcomb, at the epoch A.D. 1800. They are subject to slight variations in the course of centuries, but the effect of these will only be considered in the case of one period, the Megalosaros.

If we could find a period satisfying conditions A, B, C, D, E, we should have a perfect eclipse cycle. All the circumstances would be reproduced, even to the regions of the earth's surface from which the various phases are visible. The cycle would be rendered still more perfect from the circumstance that, owing to the exact restoration of the configurations of the three orbs concerned, all the more important lunar perturbations would return to their original values.

It may be said at once, however, that *no such perfect eclipse cycle exists*. Even could we find a perfect cycle of immense length, longer than the period covered by history, it would be of no practical use.

In the absence, then, of a perfect cycle, we have to be content with compromise, and examine how nearly the five conditions can be satisfied.

A must be rigorously satisfied in all eclipse cycles;

B must also be fairly exactly satisfied, since otherwise the eclipse will undergo a rapid change of character, and will disappear after a few returns;

C is the test of a good and useful cycle. Unless it be satisfied, it is impossible to deduce the character of a coming eclipse as regards totality or annularity, or to make any estimate of the longitudes of the regions over which its track will pass.

D. It is desirable that this should be fairly well satisfied, but it is less important than C, as the orbit of the earth round the sun is much more nearly circular than that of the moon round the earth.

E. This is the least important of the five conditions. The effect of its non-fulfilment is to shift the regions of visibility eastward or westward on the earth's surface; but this is a very simple matter to allow for, if the other conditions are satisfied.

It may be noted that where C is not satisfied, the irregularities thus arising in the Moon's longitude are so large that the discussion of condition E becomes quite meaningless. Hence in the schedule below, the word "Zero" is inserted in the 12th column in those cycles where C is not satisfied, at least approximately.

The cycles that we shall discuss in this paper are six in number:—The 4 year cycle (4^y); the Saros (Sar.); the Stockwell cycle (St.); the 300 year cycle (300^y); the ninefold Stockwell cycle (9 St.); the Megalosaros (Meg.). The abbreviated designations indicated in brackets will be used to save space.

It appears the more useful and concise plan to first give accurate statistics of the various cycles in the form of a schedule, and then to proceed to a verbal description of each in turn—its discovery, its value, its special features and characteristics.

The second column gives the length in ordinary years and days; this necessarily varies with the number of leap years included, and so is only approximate.

The fourth column gives the length in days and fractions. Dividing this length by the values of the draconitic and anomalistic months, we obtain columns (5) and (8). The nearer these columns are to exact integers the better the cycle.

The difference between the 5th column and an exact integer multiplied by 360 to reduce it to degrees gives us the 6th column. A solar eclipse is possible (on the average) when the new moon occurs, when the moon is within 16°·3 of the node, *i.e.*, along an arc of 32°·6 of the orbit. Hence we divide 32°·6 by the number of degrees in the 6th column, and so obtain the number of cycles for which an eclipse persists, which is given in the 7th column. The number thus obtained is an index of the accuracy with which condition B is satisfied. The great feature of the Stockwell cycle is the extreme accuracy with which this condition obtains; indeed, it suffices to cover the whole historical period, since the entire life-history of an eclipse would be over 20,000 years.

Of course, the test of condition E is simply that the length of the cycle should be nearly an exact number of days.

Mr. Maunder has traced out the life-history of a solar eclipse in the Saros cycle in Knowledge for October, 1893. Much of what he states there holds not only for the Sar. but for all eclipse cycles.

Thus in all the cycles an eclipse begins as a small partial eclipse near one of the earth's poles, and continues partial for about one-sixth of its whole career, the magnitude of course increasing at each return. It then becomes central (either total or annular), the track passing near that pole of the earth where the partial phase began. The tracks approach the equator at each return; the eclipse reaches the climax of its vigour when the sun is exactly overhead at mid-eclipse, and after that the track gradually approaches the opposite pole. When this is reached the eclipse ceases to be central. Its dissolution is the exact converse of its birth. It is thus partial for one-sixth, central for two-thirds, and again partial for one-sixth of its career. For example, in the 4^y cycle we should have four partial eclipses followed by fifteen central ones, and then four more partial ones; similarly in the other cases. The numbers thus obtained are *average* numbers; they may be considerably affected by the eccentricity of the orbits of the sun and moon.

It is important to know whether the tracks will move northward or southward in any particular cycle; this is decided by observing whether the number of drac. months in column 5 exceeds or falls short of an exact integer. If the former, then, at an eclipse near the ascending node, the moon will be further north at each succeeding return of the eclipse, and consequently the track on the earth's surface will also move northward. By reasoning of this kind we deduce the following laws:—

In the 4^y, St., 9 St.	Ascending Node Eclipses, or in the Sar. 300^y	Descending Node Eclipses	The tracks on the earth move north.

On the other hand—

In the 4^y, St., 9 St.	Descending Node Eclipses, or in the Sar. 300^y	Ascending Node Eclipses	The tracks on the earth move south.

The Meg. requires special discussion, in consequence of the secular changes.

To quote Mr. Maunder's article: "Each [eclipse in the Sar. cycle] is born as the second member of a pair of eclipses; each dies as the first member of such a pair." This relation also holds good in the 300^y; but in the 4^y and the St. the converse is the case; in these an eclipse begins its career as the first of a pair of partial eclipses one month apart, and dies as the second of such a pair.

There is another interesting point that we may consider before passing to the separate discussion of the individual cycles; that is, "What happens at the half-cycle?" If the number of lunations be even, and the number of drac. months even, we have a solar eclipse at the same node at the half-cycle; if the first be even and the second odd, we have a solar eclipse at the opposite node at the half-cycle. (This is the case in the St., so that we have a similar solar eclipse at the opposite node, and with the track in the opposite hemisphere of the earth after 29^y. In fact, Mr. Stockwell defined his cycle as a 29^y one, but I have preferred to use the double cycle, so as to return to the same node again.)

If the number of lunations be odd, of drac. months even, we have a lunar eclipse at the same node at the half-cycle (this holds in the Sar.); lastly, if both the numbers be odd, we have a lunar eclipse at the opposite node at the half-cycle (this holds in the 4^y and 300^y).

In all cases the half-cycle eclipse reaches its maximum vigour about the same time that the original eclipse does.

PART II.

THE FOUR-YEAR CYCLE.—The one merit of this cycle is its extreme shortness; it does not reproduce eclipses with any attempt at accuracy, but it is a convenient aid to the memory in connecting together the eclipses of different years, and in determining which years are likely to yield important eclipses. It bears an intimate relationship to Meton's famous 19-year cycle, after which new moons recur on the same days of the month (or sometimes with an alteration of one day). Since the Greeks were acquainted with this cycle, and also with the fact that the moon's nodes make the tour of the heavens in 18·600 years, they probably perceived that an eclipse was usually followed by one on the same day 19 years later. I do not know who was the first to perceive that one-fifth of the Metonic cycle was an eclipse period, but several people have noticed it independently in recent years.

SCHEDULE OF ECLIPSE CYCLES.

(1) Cycle.	(2) Approximate Length.	(3) No. of Lunations.	(4) Length in days.	(5) No. of Drac. months.	(6) Corresponding separation of New Moon from Node.	(7) Average number of times an eclipse returns.	(8) No. of Anom. months.	(9) How the criteria are satisfied. B	(10) C	(11) D	(12) E
					°						
4y	4y less 2m + 12d = $3\frac{4}{5}$y	47	1387·9377	51·00421	1·515	23	50·37054	Fair	Bad	Bad	Zero
Sar.	18y $11\frac{1}{3}$d	223	6585·3212	241·99868	0·476	70	238·99212	Good	V. Good	V. Fair	Good in trip. Saros
St.	58y less 40d = $57\frac{8}{9}$y	716	21143·9013	777·00023	0·083	390	767·34691	V. Good	Bad	Poor	Zero
300	300y less 44d	3709	109528·9525	4024·99145	3·078	12	3974·98582	Poor	Good	Poor	Good
9 St.	521y 4d	6444	190295·1117	6993·00207	0·745	43	6906·12221	Good	Poor	V. Good	Fair
Meg.	1805y 8d	22325	659270·3869	24226·99761	0·860	39	23926·00661	Good	Good	Good	Bad
Ditto in −700	"	"	659270·5472	24227·00280			23925·98205				

The 19-year period enables us to tell immediately whether any solar eclipse in Oppolzer's Canon is at the ascending or descending node. In the former case the tracks move steadily northward each 19-year period, in the latter case they go southward.

As an example of this cycle I trace the career of the Norwegian eclipse of 1896; this is in its hoary old age viewed according to the Sar., but in early youth according to our present cycle. The following table gives the principal features of this series (desc. node), also of the half-cycle lunar eclipses (asc. node):—

SOLAR ECLIPSES.

Date.	Character.	Position of Track.
1877, Aug. 9	N. Part.	
1881, May 27	N. Part.	
1885, Mar. 16	Ann.	West Canada Greenland.
1889, Jan. 1	Tot.	North Pacific, United States (West).
1892, Oct. 20	N. Part.	(Almost Annular).
1896, Aug. 9	Tot.	Norway, Siberia, Japan.
1900, May 28	Tot.	Mexico, U.S.A., Spain, North Africa.
1904, Mar. 17	Ann.	Indian Ocean, Sumatra, Philippines.
1908, Jan. 3	Tot.	Central Pacific.
1911, Oct. 22	Ann.	China, Philippines, New Guinea.
1915, Aug. 10	Ann.	Central Pacific.
1919, May 29	Tot.	Brazil, Equatorial Africa.
1923, Mar. 17	Ann.	Patagonia, South Africa.
1927, Jan. 3	Ann.	South Pacific, South America.
1930, Oct. 21	Tot.	South Pacific.
1934, Aug. 10	Ann.	South Africa, South Indian Ocean.
1938, May 29	Tot.	South Atlantic, South Indian Ocean.
1942, Mar. 16	S. Part.	
1946, Jan. 3	S. Part.	
1949, Oct. 21	S. Part.	
1953, Aug. 9	S. Part.	

LUNAR ECLIPSES.

Date.	Character.	Limb of Moon Eclipsed.	Magnitude.
1883, Apr. 22	Part.	N. Limb	0·27
1887, Feb. 8	Part.	N. Limb	0·44
1890, Nov. 26	Part.	N. Limb	0·00
1894, Sep. 15	Part.	N. Limb	0·26
1898, July 3	Part.	N. Limb	0·93
1902, Apr. 22	Tot.	...	1·33
1906, Feb. 9	Tot.	...	1·64
1909, Nov. 27	Tot.	...	1·37
1913, Sep. 15	Tot.	...	1·44
1917, July 4	Tot.	...	1·37
1921, Apr. 22	Tot.	...	1·09
1925, Feb. 8	Part.	S. Limb	0·76
1928, Nov. 27	Tot.	...	1·17
1932, Sep. 14	Part.	S. Limb	0·99
1936, July 4	Part.	S. Limb	0·28

Of course the irregularities in this cycle, *e.g.*, those of 1889, 1892, 1925, 1928, are due to the fact that conditions C, D are totally unsatisfied. For the same reason this cycle gives us no clue to the longitude of an eclipse track, or to the time of day at which the eclipse occurs.

There is a point in which this 4^y cycle may sometimes be of use. The last of a series in the 4^y is frequently the first of a Sar. series; when this is the case the 4^y serves as an index, calling our attention to the birth of a new eclipse in the Sar. It is not the case in 1953, for that eclipse is born two Saroses earlier, in 1917.

The Saros.—This cycle was discovered by the ancient Chaldæans, at a very early date, and it still remains the most perfect and serviceable of all eclipse cycles, on account of the wonderful accuracy with which conditions B, C, D are satisfied. We can, in fact, get a very fair idea of a coming eclipse without any calculation at all, by tabulating the preceding ones of the series and carrying on the differences. This appears to have been the way that the Chaldæans predicted their eclipses.

Mr. Maunder's paper, above referred to, has dealt so fully with this cycle that it is unnecessary to add much here. It may, however, be interesting to give a diagram showing the tracks of a series of eclipses, and I have chosen the series to which the eclipses of 1927, 1999 (both total in England) belong. This began its career as a small northern partial eclipse, 1639, January 4, and increased slowly each Sar.; its companion eclipse (one month earlier) lingering till 1837, April 5. Our eclipse became central, 1891, June 6 (some readers may remember this eclipse as the one visible from the Royal Observatory on Visitation Day), but the tracks of 1891 and 1909 are too far north to show conveniently. The diagram begins with the eclipse of 1927, and shows all the tracks till 2179. Even this date is not quite the middle of the series, but that is only a few Saroses later.

The southward motion of the tracks is affected by the season of the year, which accelerates it from June to December, and retards it for the other half-year. The slope of the tracks also varies with the season. The western end of the track is the highest from June to December, then the eastern end from December to June. The tracks will continue to move southward, and the eclipse will cease to be central about the year 2600, remaining partial for two or three centuries more.

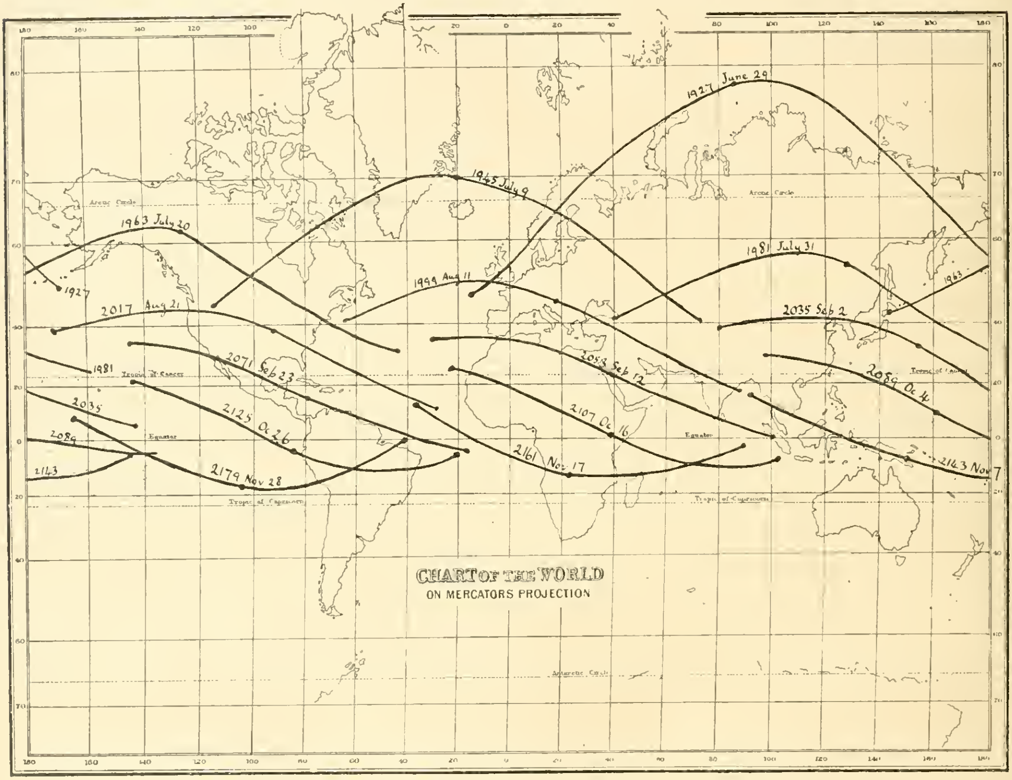


Plate I.—Diagram illustrating the Saros Cycle. The tracks of a Total Eclipse are shown from 1927 to 2179.

The half-cycle lunar eclipse began its career 1900, June 13 (north limb); it becomes total 2044, September 7, and reaches its climax about the same time as the solar eclipse, ending about the same time as the latter ceases to be central.

It not infrequently happens that two eclipses, nine years apart, at opposite nodes, pass one another about the

latitude of Europe, and give large eclipses over approximately the same regions. As examples, may be given 1715, 1724 (both total in England); 1887, 1896 (Siberia and Japan); 1945, 1954 (Norway), etc., etc. This is not sufficiently regular to be called a law, but it is worth while seeking in any European totality, whether there is another one nine years before or after.

It may be remarked that Mr. Maunder has considerably under-estimated the possible career of an eclipse in the Sar. He gives it as 71 returns, but according to Oppolzer it may reach 85 (as in the case of an eclipse that died in A.D. 676); there are seven cases of 80 returns or upwards in the Canon.

time. 1902 had three partial solar eclipses. Then follow a group of six central eclipses (two each in 1903,–4,–5). This year's eclipses are in their decrepitude, and end their career as central eclipses in 1957 and 1939 respectively. Next year's eclipses are in full vigour, while those of 1905 are in comparative youth and began their central career in 1598, 1797 respectively.

The Sar. may be used to give, without calculation, a rough position of the moon at any time in a year for which no Almanac is available. Thus, suppose we desire to obtain a rough place of the moon at 11 p.m. on March 21, 1921. We take from the Almanac its place one Sar. earlier. [Note that the Sar. consists of $18^{y}\ 12\frac{1}{3}^{d}$ when three 29ths

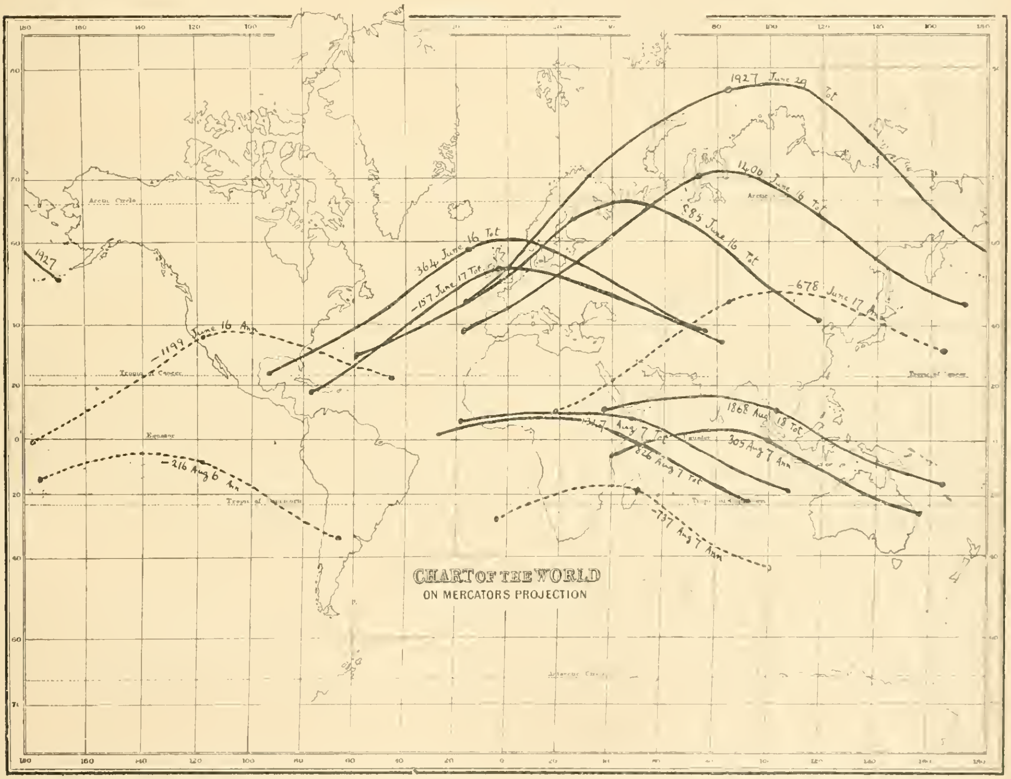


PLATE II.—Diagram illustrating the past history of the Eclipses of 1868 and 1927 in the 521-year Cycle.

The following is an easy way of diagnosing the approximate age of a central eclipse in the Sar.

A glance at Oppolzer will show that we have generally a group of partial eclipses (2, 3, or 4), followed by a group of central eclipses (4, 5, or 6), of course separated from one another by six months. Then we can infer that the central eclipses at the beginning of such a group are in their decrepitude, those in the middle of the group are in their full vigour, while those at the end of it have just began their central career. In a word we may apply the adage "Seniores priores" to the group, which is often a useful aid to the memory.

As an example we may take the eclipses of the present

of February are included in the interval, $18^{y}\ 11\frac{1}{3}^{d}$ when four are included, $18^{y}\ 10\frac{1}{3}^{d}$ when five are included.]

In this case five 29ths of February are included, hence the corresponding date is 1903, March 11^{d} 3 p.m.

We take from the Almanac the age of the moon at this time, viz., 12·2 days; this will also be its age at the epoch required in 1921.

We also take its R.A. and Dec., viz., R.A. $9^{h}\ 42^{m}\cdot4$, N. Dec. 92° 27′, insert this on a star map, and then shift it eastward 10°·8 parallel to the ecliptic. The result is a close approximation to the place of the moon at the time named; in this case we obtain $10^{h}\ 29^{m}\cdot1$, N. Dec. 6° 3′.

As another example, the age of the moon at noon,

March 8, 1899, was 26·1 days. Going back four Saroses we reach 1809, January 12ᵈ 8ʰ p.m., when the moon's age would have been about the same. This was the date of the death of Sir John Moore, and we thus see that the lines "By the struggling moonbeams' misty light," in Wolfe's beautiful poem, are not strictly in accord with astronomical facts.

THE STOCKWELL CYCLE.—This is chiefly interesting for the extraordinary accuracy with which condition B is satisfied; it is not a good cycle in any other respect. The ninefold cycle is better, as it satisfies condition D accurately and C roughly. A diagram is given showing the past history of two eclipses in this cycle, viz., those of 1868, 1927.

It will be seen that several of the tracks repeat themselves very well; thus those of −157, 364, 885, 1406, 1927, are all total in or near the British Isles. We cannot, however, have great confidence in the longitude of a track predicted by this cycle: for example, the tracks of −1199, −678, also those of −737, −216, show a great shift in longitude. We can, however, predict the latitude very closely, as the diagram shows.

(To be continued.)

Letters.

[The Editors do not hold themselves responsible for the opinions or statements of correspondents.]

THE SURROUNDINGS OF THE "AMERICA" NEBULA.

TO THE EDITORS OF KNOWLEDGE.

SIRS,—In the July number of KNOWLEDGE Dr. Max Wolf states: "Photographs of this fine nebula have been published not only by myself (KNOWLEDGE, 1902), but also within the last few months by Dr. Roberts and by Professor Barnard." I wish this statement, which is inaccurate so far as I am concerned, to be corrected. My photograph of the nebula was taken on October 10th, 1896, and was published in KNOWLEDGE, November number, 1898, which chronological computations would sum up to 81 months. This fact is not fairly represented by Dr. Wolf's words "within the last few months." I have also compared the photograph here referred to with mine published in 1898, and find vast differences, in favour of my reflector plate, in the structural details that are delineated. The letterpress which accompanied the photograph explained that the nebula extended beyond the boundaries of the plate.

Is it desirable, in these modern days, to attach the names of countries, towns, cities or of individuals to nebulæ or other objects in the sky? Of course we may excuse the harmless lunacy of designating by the names of individuals objects seen on the moon; but, if the practice is to be extended to the designation of objects which can be photographed in the sky, there should be some method of selection, and I do not see the reason of attaching the name of America more than of England to the nebula here referred to. It was first photographed, on a scale that is suitable for scientific investigation, at Starfield, but I should object to change its designation of H V. 37 *Cygni* because Sir William Herschel was the first to discover it; and, further, I object to all fanciful designations that may involve controversies.

Starfield, Crowborough. ISAAC ROBERTS.

PROTECTIVE RESEMBLANCE IN BUTTERFLIES.

TO THE EDITORS OF KNOWLEDGE.

SIRS,—Some years ago I made a small collection of butterflies in the district of Santos, Brazil, and amongst them are two specimens obtained from the granite quarries, which in colour and markings exactly reproduce the texture of granite. I have no doubt this is an instance of ordinary protective resemblance, for I remember how difficult it was to see these butterflies when once they settled on the granite surface. The point, however, which strikes me as of considerable interest is that the general colouring of the butterfly is a cool blue grey, exactly the shade of the freshly-quarried stone, on which it invariably settled. The weathered surfaces of the granite were greenish-grey.

The facts seem to point to a very rapid evolution of the butterfly's present colouring, since the quarries in question have probably only existed for some 200 years, and before that time the butterflies could not have found access to a freshly-cleft granite surface.

I am not entomologist enough to name the butterfly, but would send a photograph to anyone interested.

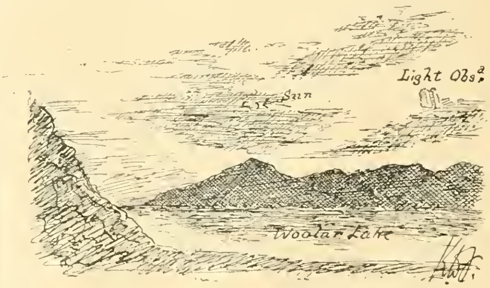
I should be glad if any of your correspondents who have studied the question of protective colouring could say whether there is any warrant for concluding that a change in colour of the kind indicated could be evolved within so limited a period. W. S. ROGERS.

[This observation is of much interest, and there can be little doubt that the colour of the species has changed during the period mentioned under the influence of natural selection. During the last half of the nineteenth century British entomologists have noticed a distinct tendency on the part of certain moths, normally of a pale grey colour, to be replaced by dark varieties, in the manufacturing districts of the north of England, where the habitual resting-places of the insects—palings, tree-trunks, &c.—tend, through the deposition of soot, to be darker than usual. It must be remembered that a century or two is a comparatively long period in the life of a species of insect. —G. H. CARPENTER.]

CURIOUS SUNSET PHENOMENON.

TO THE EDITORS OF KNOWLEDGE.

SIRS,—On the 4th July, I observed a curious phenomenon in conjunction with the sunset of that date. The sun was, roughly, at an altitude of ten degrees above the horizon at the time, and partially obscured by dense dark



clouds, which, together with a faint haze, hung over the low hills which bounded the horizon in that direction. At about 7 p.m. my attention was drawn to an exceedingly bright patch of light, of irregular shape, which exhibited

the spectrum colours with great distinctness (red nearest the sun), and appeared in the north-west, about thirty degrees from the sun and at the same altitude. From the time that I first noticed this (I had previously been looking in a different direction) the light diminished in brightness, and finally, after about fifteen minutes, faded away. The corresponding portion of the sky on the other side of the sun, *i.e.*, thirty degrees from the sun in a south-westerly direction, was not visible from my position, but I was unable to observe anything similar above or below the sun. There was no actual cloud where the light appeared, though there was just below it. The temperature was about 60° Fah., and on return to camp the barometer gave a reading of 24·56″ (altitude 5183 feet above sea).

I trust some reader of Knowledge will be able to explain this, and that some other Indian reader may record his impressions of this phenomenon.

K. D. Field, lt.r.a.

Kashmir.

Notes.

Astronomical.—The interesting variable, or "new" star near the Ring Nebula in Lyra (designated 10, 1903 Lyræ), which was discovered some time ago by Herr E. Silbernagel, has been fully investigated at the Lick Observatory. Photographs taken by Prof. Keeler in 1899 show the star to have been then of the 17th magnitude, but in April of the present year it had risen to the 12th magnitude. A spectroscopic investigation made with the small slitless spectrograph shows the presence of bright lines, but in spite of this the spectrum has little similarity with that of novæ The observations leave little doubt the star is a variable, and not a nova, and that it belongs to the class of variables which exhibit bright lines of hydrogen at maximum. The spectrum is, in fact, almost an exact counterpart of that of R Draconis. The position of the star (1900) is 18h. 50m. 27s. + 32° 42′ 21″.

The issue of "Bulletins" from the Lowell Observatory, Flagstaff, Arizona, is inaugurated by an interesting account of the observations of the projection on the terminator of Mars, which excited such general interest towards the end of May. From the micrometric measurements it appears that the projection, which was three hundred miles in length on May 26th, but had almost disappeared on the following day, travelled over the surface of the planet at the rate of sixteen miles an hour. It, therefore, could not have been the illuminated summit of a mountain, and Mr. Lowell concludes that it was an enormous cloud. He further expresses the opinion that it was not a cloud of water vapour but a cloud of dust, and he states that other phenomena of the planet bear out this supposition.

Additional evidence of the physical connection of the two components of 61 Cygni is furnished by a spectroscopic investigation of their movements in the line of sight which has been made by Mr. Adams at the Yerkes Observatory. The mean results are 62 and 63 kilometres per second, towards the sun, for the two stars, and this agreement, together with the similar proper motions of the two stars, indicate that they are unquestionably physically connected. Their real motion in reference to the sun, under the assumption of a parallax of 0″·4 and a proper motion of 5″·2, would be about 80 kilometres, or, in space, when corrected for the solar motion, about 64 kilometres per second.—A. F.

Botanical.—One of the most interesting instances of irritability in plants is met with in *Masdevallia muscosa*, a diminutive orchid of no horticultural value, but remarkable in the sensitiveness of its labellum. The plant has been known for many years, and the peculiar character of the labellum was the subject of an elaborative paper in the first volume of the *Annals of Botany*, by Prof. F. W. Oliver. It was exhibited at the Royal Society's Soirée on June 19th, and may still be seen in flower in Kew Gardens. Its irritability may be compared to that of the Venus Fly Trap. In this, it will be remembered, the parts that receive the stimulus are the three bristles found on each half of the leaf-blade, and it seems to be conveyed from them to other points where the movement actually takes place. In the orchid it is the crest of the small triangular labellum that receives the stimulus, but the movement occurs at the narrowed base of this organ, called the neck, and the labellum is caused to spring upwards against the column, forming with other parts of the flower a small chamber having only a very narrow opening at the top. The purpose of the sensitive labellum is evidently to aid in the cross-fertilization of the flower. An insect on touching the crest is at once made a prisoner by the springing up of the labellum, but it eventually escapes by crawling through the aperture at the top of its prison. In doing this, however, it is obliged to brush against the pollinia, which it carries away, transferring them to the stigma of another flower while it is struggling to escape from a second term of captivity.

It is not uncommon for peduncles or pedicels to elongate a little after the flowering period, and during the ripening of the fruit; but to have a pedicel, which at the flowering stage is scarcely more than a quarter of an inch long, growing to a length of six or seven inches is a very unusual occurrence. This, however, takes place in a small parasitic orchid, *Didymoplexis pallens*, which is now to be seen in flower at Kew. The whole plant is usually less than six inches high, and the flowers are small, brownish white, and unattractive. The elongated pedicels are quite erect, and the remarkable growth in length is accompanied by a considerable increase in thickness; but it has been observed that only the pedicels of flowers which have been fertilized possess this peculiarity. The plant is widely spread in India, and is found also in Perak, growing in the bottoms of tropical valleys, usually under clumps of bamboos, on the roots of which it appears to be parasitic. The growth of the pedicel is supposed to be for the purpose of carrying the fruit well above the decaying vegetable matter in which the plant grows.—S. A. S.

Zoological.—In the article on giant tortoises published a few months ago in Knowledge, it was stated that the earliest known members of the group date from the Pliocene (or possibly the late Miocene). Recently, however, these reptiles have been carried back to a much earlier period in the earth's history by the discovery of the remains of a species in the upper Eocene formation of the Fayum district, Egypt. The remains of the species in question have been described by Dr. C. W. Andrews in the publications of the Cairo Survey Department, and named *Testudo ammon*. In addition to thus carrying back the existence of giant land tortoises to such a comparatively remote epoch, the discovery has a wider interest. For if creatures of such an essential modern type date from strata of undoubtedly Eocene age, there may be something to be said in favour of the view of the Argentine palæontologists as to the early Tertiary age of the mammaliferous beds of the Santa Cruz district of Patagonia, a

view which has been generally discredited in Europe on account of the specialised character of the fauna.

According to Dr. R. Broom (*Proc. Linn. Soc. New South Wales*, 1902, p. 4), considerable modification must be made with regard to the homology of certain bones in the base of the skull of lizards and other reptiles and amphibians. Hitherto a pair of bones in the front of the skull have been correlated with the mammalian vomer. These, however, Dr. Broom calls prevomers, and identifies with the so-called dumb-bell bone of the duckbill; while the true vomer is represented by the large sheet-like bone on the hinder part of the base of the skull of amphibians hitherto known as the parasphenoid, this bone being also present in a rudimentary form in lizards.

In the *Zoologist* for July Mr. Lydekker described the Burmese representative of the gaur, or wild ox of India, as a new race, under the name of *Bos gaurus readei*; the chief distinctions from the typical race being the presence of a tuft of long hair on the dewlap and a difference in the form of the horns.

The form of the skull of the gigantic toothless pterodactyle (*Pteranodon*) of the Cretaceous of Kansas gives rise to the suggestion, according to Mr. G. F. Eaton (*Amer. Journ. Science*, July, 1903), that these monstrous flying reptiles were furnished with a capacious gular pouch, comparable to that of the pelicans. This is in accordance with the supposed fish-eating habits of *Pteranodon*.

Great interest attaches to the discovery, during excavations in the base of a house in Salisbury Square, E.C., of the nearly perfect skull, minus the lower jaw, of the woolly Siberian rhinoceros. The specimen, which was found in a bed of peat, is reported to be the finest and the most nearly complete ever discovered in this country, being rivalled in this respect only by examples from the Siberian tundra. At a short distance from the skull were dug up a half of a lower jaw, the head of a thigh-bone, and a few ribs; the former, it is said, pertaining to a species other than the woolly *Rhinoceros antiquitatis*.

In a recent issue of the *Proceedings* of the Royal Society Prof. W. J. Sollas, of Oxford, demonstrates that the so-called Palæozoic lamprey (*Palæospondylus gunni*), from Devonian strata, is in reality a primitive fish-like creature, exhibiting signs of affinity with the lampreys, the sharks, and the young of lung-fishes or amphibians. It probably diverged from the main stem previous to the differentiation of the sharks and rays, and pursued an altogether independent line of development. Prof. Sollas's method of investigation was by making thin transverse sections of a number of specimens.

More than twenty years ago Prof. T. Eimer showed that among lizards the following changes in colour-pattern are very commonly observable. First there are longitudinal stripes, which break up into spots; the latter coalesce to form transverse bars, which finally disappear and leave the skin of one uniform tint. In some lizards the whole of these stages are passed through during life, but in others only the second or even the first stage is reached, while in yet others commencement is made with the second or some later stage. From these facts Eimer advanced the theory that the same series of colour-evolution has occurred in the animal kingdom generally. Recently Dr. H. Gadow, of Cambridge, in a paper contributed to the *Proceedings* of the Royal Society, has tested Eimer's observations in the case of certain Mexican lizards, and finds that in the main they hold good. It appears, however, that it is only in certain stations these changes take place, so that they are limited to particular races or breeds, in which, moreover, only some of them occur. It is believed that the changes are due to differences in the amount of light received in the habitat of these particular breeds, and therefore that they are protective in their nature.

If American methods are continued much further on the present lines, Zoology, so far at any rate as mammals are concerned, will become a well-nigh impossible science to all save specialists of the narrowest type. In addition to others named during past years, Mr. G. S. Miller has recently described no less than fifteen chevrotains, or mouse-deer, from Malaysia as new species; the form from each islet being regarded as a distinct species. Those named by Mr. Miller from 1900 to 1902 have already been relegated to the rank of sub-species by Mr. J. L. Bonhote in a paper published in the March issue of the *Annals of Natural History*, and there is no doubt that this is the right way of dealing with such local variations, as they can then be disregarded by all but the specialist.

Notices of Books.

"RADIANT ENERGY AND ITS ANALYSIS." By Edgar L. Larkin, Director Lowe Observatory, Echo Mountain, California. (Baumgardt Publishing Company, Los Angeles, California. 1903.)—This work is different from any other text-book on astrophysics which we have seen. We cannot say it is more profound; we cannot say it is more lucid; but it is different. It is, perhaps, because of our imperfect acquaintance with the American language, but sometimes we could not do more than make a shrewd guess at the meaning of some of the paragraphs. For instance, on p. 17, we read: "These two, matter and energy, or possibly one, is the sum total of all that has been found during three centuries of incessant research in all that portion of the universe visible in a forty-inch telescope armed with the most powerful spectroscope ever made." We judged that the first clause meant that perhaps matter and energy were alternative forms of the same thing, but on page 41 we read: "Thus the undulatory theory of light was proven, for matter added to matter cannot destroy both—light is therefore not matter." We had always understood that light is a form of energy. And again on p. 289, "What mighty import hovers round the word evolution. For giant modes of energy wrought and struggled in war. Matter was shaken, oscillated, kneaded, boiled and trembled in the throes of chaos. Phantom forms of nebulæ were clutched in awful churning, in seething whirlpools, and throbbed with energy. Absolute zero and darkness reigned, useless indeed; cold light can be in the most frigid space." Evolution, indeed, he has found to be a blessed word, though we cannot hazard a surmise as to what sort of fearful wild fowl he considers it to be. In his summary on p. 293, he says, "That evolution set its mighty clutch on all existing matter when it was in an excessively rare ultra-gaseous or corpuscular state, filling all space now occupied by seas," and then in a page of emphatic though somewhat obscure description he traces the history of the Cosmos from that time until, "through contraction, heat developed, and light on small worlds after nearly all the heat had vanished, water came, and coarse life, then more refined, and lastly mind, along towards the close of evolution. It contemplates the stupendous scene for a few seconds and disappears." It may be from faulty proof-reading, or from the peculiarity of the language, but in very many instances the verbs and nouns do not agree, and we think that the meaning might be somewhat clearer if they did. But it is the index that we find of most unexpected interest. In casually glancing through the Ms, we found wedged between "Miss Maury, Measurement of Graphs," and "Meridian Photometer," the reference "Men, Pale and Faint." On turning to p. 285, which was indicated, we read, "The new sun in Perseus last year was seen to resolve into a chaotic nebula. Mystery

deepens, while men pale and faint in presence of these mighty problems." After this it was a distinct disappointment to find that a statement on p. 231, "The planetary heavens would burn as heated brass, and the heats of Pelée and Soufrière would pale and faint," was not similarly indexed. The book is distinctly original, very amusing, and though we would not recommend it as a text-book to the young and innocent aspirant to scientific honour, we note with the most pleasurable anticipation that the author says in the "Introductory" that "enough material is now on hand to fill another volume like this."

"Geological Rambles in East Yorkshire." By Thos. Sheppard, F.G.S. Pp. xii. and 236. With about 50 illustrations and a coloured geological map. (London: A. Brown and Sons, Ltd.)—This handsomely printed book is dedicated to Messrs. P. F. Kendall and G. W. Lamplugh, and the frequent references to the work of these geologists shows under what a powerful spell the author has fallen in his rambles on the Yorkshire coast. On p. 31 he writes, with a welcome and just enthusiasm, "to such an extent is Mr. Lamplugh connected with the geology of this district, that to speak of the latter without the former would be equal to playing 'Hamlet' without the Prince of Denmark." Throughout the descriptions, the reader feels that he forms one of a friendly party, to which the untiring zeal of Mr. Kendall, or the penetrating geniality of Mr. Lamplugh, furnishes a continuous inspiration. Mr. Sheppard is content to act as the recorder, and there is no reason to doubt his accuracy in so doing.

The author makes, perhaps, too much claim on the knowledge of the reader at the outset. We should have liked to start with a sweeping survey, a comprehensive view, from the great plain of York, fit for the civilisation of imperial Rome, to the bare Wolds eastward, and thence to the strange and shifting coastland, which seems to connect Yorkshire with the flats of Holland and the Baltic. The course of the Derwent, again, excites the imagination when set down upon the map. We have a right to look for some geographical grasp from those who offer themselves as geological guides in so interesting a country.

The remarks on pp. 110—111 as to the value of fossils in recording the history of a district are clearly addressed to the untrained visitor. But we want more such explanations, and to find them in the opening chapters, if the book is aimed at the majority. What will the ordinary reader make of the zoning of the Speeton clay (p. 67), or the terms Cretaceous, Oolitic, and Liassic on p. 38, or the phrase "oolitic sandstone" on p. 136, where "oolitic" is probably used in its unfortunate stratigraphical sense, as on p. 109, and in the table on p. 101, and not lithologically, as one would suppose from the statements on p. 92. Surely it is time that the international term Jurassic should displace our local and misleading terminology. We cannot do away with "Carboniferous Limestone," or "Cretaceous Chert"; but a way has been opened by which we can avoid "Middle Oolite," "Lower Oolite," and so forth. On p. 92 the author uses the word Jurassic, but, by a slip, as equivalent to the "Oolitic system."

A few phrases in an otherwise clear and readable book require emendation. On p. 47 we learn that "the discovery referred to consisted of a streak of greenish coloured sand, about 24 feet long, and rarely exceeded 4 inches in thickness." On p. 133, the whorls of an ammonite are said to be "divided into a number of septa or cell walls," instead of into a number of chambers. On p. 55, it is implied that great earth-movements have not taken place in Britain since Palæozoic times. A study of the Isle of Wight or the Dorset coast would surely have corrected this impression. Yet a certain ingenuousness on the part of the author, and his delight in the features of his chosen locality, disarm the professional geologist, who wants to look at all things from the point of view of effectiveness in a lecture-room. Let us thank Mr. Sheppard for a distinctly helpful volume, and for such fine illustrations as those of Bempton Cliffs (p. 41), the Boulder-clay of Filey (p. 74), and the Gristhorpe coast with its overhanging cornice (p. 89); in addition to which many others should be mentioned.

"An Introduction to Botany." By W. C. Stevens. Pp. viii. and 436 and 127. Ff. 350. (Heath & Co.) Price 6s.—In this excellent text-book the author emphasises the importance of practical work. The chapters open with observations for guidance in this, followed by a discussion on the leading points. Preliminary remarks on laboratory work precede a series of chapters dealing with the various parts of plants, beginning with seeds and seedlings and passing on to flowers. The remaining chapters will afford the beginner a general view of the subject. The book is written by an American Professor, primarily for American students, hence the "Flora" at the end is naturally a selection of American plants.

"Astronomy for Everybody." A Popular Exposition of the Wonders of the Heavens. By Prof. Simon Newcomb, LL.D. (London: Isbister & Co.) 1903. Pp. xvi. and 341. 7s. 6d.—Despite the great promise of the introductory chapter, we must confess to a feeling of disappointment with this book as a whole. While giving an orderly elementary account of astronomical phenomena and the uses of the principal astronomical instruments, it seems to us to deal inadequately with the kind of observations which everyone may make, and also with the revelations of the telescope. It is besides difficult to understand why Prof. Newcomb has not availed himself to a greater extent of the wealth of material now available for the purpose of illustration. Many of the diagrams are unattractive, and the reproductions of photographs, which are only four in number, are not by any means excellent. Nebulæ, of which so many magnificent photographs have been taken in recent years, are not pictorially represented in any shape or form, and the forms of comets are only exhibited by three very inferior drawings of Donati's comet of 1858. It may also be pointed out that the path of the rays in a Newtonian reflector is incorrectly shown in Fig. 13. As might be expected, the text is thoroughly trustworthy and interesting so far as it goes, and the reader who masters it will have but little to unlearn if he should happily be induced to pursue his studies. It should be noted, however, that the doubt expressed on p. 148 as to the presence of dark lines in the spectrum of the corona is no longer justified, and also that no considerable proportion of the lines in the spectra of the Orion stars are now to be attributed to unknown substances (p. 295).

"On the Distribution of Rain over the British Isles during the Year 1902." Compiled by H. Sowerby Wallace and Hugh Robert Mill, D.SC., LL.D. (Stanford.) 10s.—No country in the world possesses so excellent a corps of rainfall observers as the British Isles. There are no less than 3500 of them, and their observations are here given for the year 1902. "British Rainfall" is as familiar as household words to meteorologists, but it is a publication that engineers, agriculturalists, sanitary authorities, and others will also find of service and interest. If such refer to this book they will find no difficulty in learning whether any statistics are available for any given locality, because the excellent way in which the stations are grouped into counties makes the search easy. With such a multitude of stations it is, of course, not feasible to give detailed observations for them all, so that in the majority of cases only the total fall for the year is given, together with the number of days during the year on which rain fell. But it is not enough merely to know the amount of rain that fell, since for many purposes it is desirable to learn what happens to the rain when it reaches the ground. To this end, therefore, this book includes for a few stations observations concerning evaporation and percolation, although it could be wished that still more figures concerning these important factors were available. The tables showing the number of droughts experienced during the year will prove of great utility, fifty representative stations being chosen for investigation. Another important point concerning water-courses and their capacity for carrying off storm water is elucidated by the note on heavy rains experienced during short periods, and also by the table which records the number of days that had unusually heavy rains. Mr. Wallace would appear to think that the interest in the record of a year's rainfall must to some extent wane in the six months necessary for its publication; but he and Dr. Mill are to be congratulated on the quickness with which they have published this volume, a quickness, it may be said, that could be imitated by other meteorologists with advantage.

"The Structure of the Nucleus." A continuation of "Experiments with Ionized Air," by Carl Barus. (Smithsonian

Contributions to Knowledge. 1903.)—This valuable memoir is a continuation of the "U.S. Weather Bureau, Bulletin 12" (1893), and of the "Smithsonian Contributions to Knowledge," Vol. XXIX. (1901), by the same author, and but for a little prefatory "advertisement" by Prof. Langley it would be very difficult for the reader to understand Prof. Barus' present researches without a careful study of the previous works. Even as it is, it is much to be regretted that Prof. Barus has not given a concise summary of the objects, methods and results of the two previous papers; and especially has not clearly defined both "nucleus" and "corona," and given a description or representation of some of the forms of the latter. Apparently nuclei are extremely small particles tending to precipitate water from moist air, when this is suddenly cooled, and in the present researches they were usually supplied by introducing into the receiver air which had passed over phosphorus, or burning sulphur, or glowing charcoal. They could be obtained, however, without putting anything material into the receiver, by passing the X-rays or other form of radiation through it. Here the production of nuclei in case of weak radiation is very gradual, and it takes time to produce them, but when once produced they show a degree of persistence identical with that of nuclei of any other origin. Since there is no qualitative difference referable to their origin, the stuff out of which their nuclei are made must be in the gaseous contents of the receiver (air or vapour). The chief aim of the memoir is to throw light on the phenomena connected with the presence of nuclei in air by aid of the "coronas" or colour rings seen in such air where its moisture is condensed and deposited on the nuclei, and a distant source of light is looked at through the turbid medium. The author accepts the theory that nuclei which vanish are absorbed on contact with the walls of the vessel, and that no other loss of nuclei occurs. Nuclei are sparsely distributed (10^2 to 10^6 per cub. cm.) in comparison with molecules. In using an emanation of phosphorus as an ionizer, the author found incidentally that, under certain conditions, the emanation produced permanent conduction in the condenser. This he identified with the occurrence of traces of moisture, but the behaviour so closely resembled the effects of radio-activity, that he concluded that the latter quality could only be predicated with extreme caution.

BOOKS RECEIVED.

Treatise on Zoology. Edited by E. Ray Lankester, M.A., LL.D., F.R.S. Part I.—*Introduction and Protozoa.* By J. B. Farmer, D.SC., F.R.S.; J. J. Lister, M.A., F.R.S.; E. A. Minchin, M.A.; and S. J. Hickson, F.R.S. (A. & C. Black.) Illustrated. 15s. net.

Memoirs of the British Astronomical Association. Fifth Report of the Section for the Observation of Mars. 3s.

The Crowd. By Gustave le Bon. (Fisher Unwin.) 6s.

Buddhist India. By T. W. Rhys Davids, LL.D., PH.D. (Fisher Unwin.) 5s.

Fundamental Problems. By Dr. Paul Carus. (Kegan Paul.) 7s. 6d.

Position of the Old Red Sandstone in the Geological Succession. By A. G. M. Thomson, F.G.S. (Dundee: John Leng & Co.)

School Geometry. Part III. By H. S. Hall, M.A., and F. H. Stevens, M.A. (Macmillan.) 1s.

Smithsonian Institution. Report of the U.S. National Museum for the Year ending June 30th, 1900. (Washington: Government Printing Office)

Smithsonian Institution. List of Publications, 1846–1903.

Doubts about Darwinism. By a Semi-Darwinian. (Longmans.) 3s. 6d.

Elementary Chemistry of Photographic Chemicals. By C. Sordes Ellis, F.I.C., F.C.S. (Hazell, Watson & Viney.) 1s. net.

The Surd of Metaphysics. By Dr. Paul Carus. (Kegan Paul.) 5s. 6d. net.

Karma. By Dr. Paul Carus. (Kegan Paul.) 1s.

Practical Management of Pure Yeast. By Alfred Jörgensen. *(Brewing Trade Review.)* 5s. net.

Portraiture for Amateurs without a Studio. Parts I. and II. By Rev. F. C. Lambert, M.A. (Hazell, Watson & Viney.) 1s. net.

Economic Ideals. By James Dundas White, M.A., LL.D. (F. R. Henderson.) 2s. net.

Steel and Iron. By Arthur H. Hiorns. (Macmillan.) 10s. 6d.

Algebra. Part II. By E. M. Langley, M.A., and S. R. N. Bradley, M.A. (Murray.) 2s.

Physical Chemistry. By Dr. Ernst Cohen. (Geo. Bell & Sons.) 6s. net.

Traverse Tables. By Robert Shortrede, F.R.A.S. (Layton.)

Notes of My Life. By George Wyld, M.D. (Kegan Paul.) 3s. 6d. net.

Bulletin de la Société Astronomique Flammarion de Montpellier. July, 1903.

Prevalence of Gales on the Coasts of the British Islands during the 30 Years, 1871–1900. By Frederick J. Brodie, F.R.MET.SOC. (Royal Meteorological Society.)

Catalogue of 1520 Bright Stars. (Cambridge Observatory, Mass.)

Provisional Catalogue of Variable Stars. (Cambridge Observatory, Mass.)

Marl-Slate and Yellow Sands of Northumberland and Durham. By Prof. G. A. Lebour, M.A., M.SC., F.G.S. (Andrew Reid & Co.)

Institute of Mining Engineers. Thirteenth Annual Report of the Council. (Andrew Reid & Co.)

Phthisis Viewed in Relation to Dartmoor, to Devonshire in General, and to Constitution. By William H. Pearse, M.D. (Baillière, Tindall & Cox.)

Carbon Photography Made Easy. By Thomas Illingworth. (Iliffe.) 1s. net.

The Boiling Lake of Dominica. By F. Sterns-Fadelle. (Dominica: *The Dominican* Office.) 1s.

THE VATICAN OBSERVATORY.

By W. Alfred Parr.

When towards the middle of the ninth century Pope Leo. IV. sought to stem the further ravages of the Saracen hordes by strengthening the defences of Rome and enclosing the Vatican hill with massive turreted walls, he could little imagine that these same walls, designed so well to bear the engines of war that were to dominate the country round, would, more than a thousand years later, be required by a successor and namesake to harbour a weapon of science of a potency little dreamt of in those days—a weapon whose range of power should penetrate to the confines of the unknown itself. For, after the conclusion of the International Photographic Conference on the charting of the heavens, held in Paris in 1889, it was on one of the strongest of the towers forming part of the ancient Leonine wall that the late Pontiff, Leo XIII., decided to erect the newly-ordered astrographic telescope which was to enable the Vatican Observatory, until that time somewhat meagrely equipped, to worthily enter the lists with the seventeen other observatories to whom the work of the chart had been allotted.

The history of the Vatican Observatory is no less interesting than varied. Closely associated in its earliest years with one of the most memorable achievements in the annals of mathematical science—the reform of the calendar in 1582, under Gregory XIII.—it was shortly afterwards suffered to lapse into complete neglect for nearly a century and a half. Gregory, however, may be said to have founded the observatory when he erected that lofty portion of the Vatican Palace known as the "*Torre dei Venti*," not, as some rather uncharitably maintained, in order merely to enjoy the extended view obtainable from its summit, but in order to institute the study of celestial phenomena in general. That the latter purpose was the true one seems amply evidenced by the tower being referred to in the inscriptions as the "*turris astrorum speculatrix*," and by the fact that it contained the meridian line, constructed to demonstrate to Gregory that, in his time,

the sun no longer entered the sign Aries on the orthodox 21st of March; a circumstance which, as seriously affecting the date of Easter, gave Gregory the opportunity of conferring a lasting *éclat* on his pontificate by undertaking the long-desired reform of the calendar. This reform, projected by the Neapolitan physician and astronomer, Lilio, and afterwards more fully demonstrated by the Jesuit, Clavius, was established by papal brief in 1582, but so strong was the feeling against the measure in all countries not adhering to the Church of Rome that it was not adopted by Germany until after the energetic representations of Leibnitz and others in 1700, nor by England until more than half a century later, when its introduction met with the greatest opposition, while

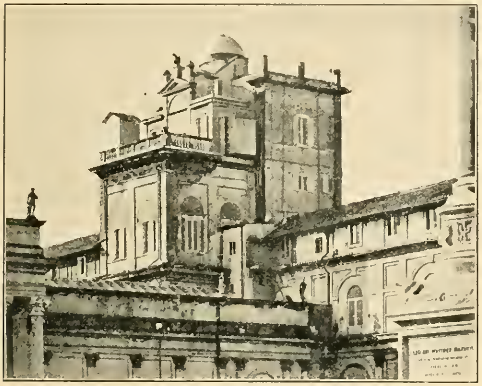


FIG. 1.—The Gregorian Tower of the Vatican Observatory.

Russia disregards it even to-day. The significant appearance on the official seal of the Vatican Observatory of the Ram's Head, symbolical of the sun's position at the vernal equinox, still serves to commemorate the connection between the Gregorian Tower and the Gregorian Calendar. Though, from its height of 73m. above sea-level, well enough adapted for the astronomical work of those times, the "Tower of the winds" did not long enjoy its reputation as an observatory, and it was only towards the end of the eighteenth century that it began, in a measure, to regain the importance of its earlier days. Meteorology, however, rather than astronomy, now formed the chief study, for it had been found that, as the vast dome of St. Peter's somewhat impeded the view towards the south, the site was less favourably placed for astronomical work than that occupied by the observatory of the Collegio Romano, erected in 1787, and rendered famous through the labours of De Vico and his illustrious successor Secchi. Nevertheless, for some thirty years after 1789 the Vatican Observatory continued to display considerable activity in observational work under Gilii, but after his death in 1821 it again fell into disuse, the instruments becoming gradually dispersed and the place itself deserted, until, after the political events of 1870, when the Italian troops took formal possession of the Eternal City, and Pius IX. entered upon his self-imposed imprisonment in the Vatican, the locale of the observatory, owing to the exigencies of space, was finally transformed into dwelling apartments.

But in spite of this fall, the strangely chequered fortunes of the venerable institution were not to end here, for the observatory was soon to enter upon the last and most active period of its existence—that which recognises in it the well-known and well-equipped *Specola Vaticana* of to-day. The immediate cause of this resuscitation was the scientific exhibition held at Rome in 1888 to commemorate the Jubilee of Leo XIII. At its close the late Father Denza, whose name had been for many years before the scientific world, suggested to the Pope that the collection of instruments forming part of the exhibition should be made use of to reconstitute the Vatican Observatory. This project not only met the immediate approval of Leo XIII., himself a mathematical prizeman of earlier years, but was so enthusiastically carried through that by the summer of 1889 Denza had nearly all his instruments installed, and was able to attend the International Photographic Congress at Paris as representative of the Vatican Observatory, and to claim for the newly reconstructed institution a place among the eighteen great observatories taking part in Admiral Mouchez's grandiose scheme of charting the heavens. Under the formal directorship of Denza the observatory was now equipped with all the most modern meteorological, magnetic, and seismological instruments, many of them being the first to be introduced into an Italian observatory, while its purely astronomical department was enriched by the addition of the astrographic telescope constructed in Paris by the Brothers Henry, and mounted by Gautier, of the Paris Observatory. This instrument, which, like its Paris congener, is mounted on the so-called English system, is carried on piers of white Carrara marble, and consists of the usual pair of telescopes contained in a rectangular case of metal, the photographic telescope having the regulation aperture of 33 cm. to a focal length of 3·43 m., and the visual one an aperture of 20 cm. to 3·60 m. focal

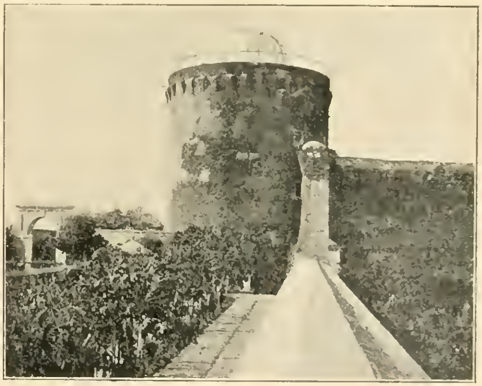


FIG. 2.—The Leonine Tower.

distance. It was placed in position in May, 1891, on the strongest of the towers belonging to the ancient Leonine wall mentioned above.

Curious as was the anachronism of fitting one of the most specialized products of the nineteenth century to a structure dating from the ninth, the old Leonine tower nevertheless proved itself admirably adapted for the novel purpose to which it was put; for situated as it is on the summit of the Vatican hill some 400 m. distant from the Gregorian tower, with which it is in telephonic communication, and, with its colossal walls of over 4 m. thickness, almost a monolith in strength, it unites in the happiest manner the elements of isolation and solidity so essential

to the delicate nature of the work carried on beneath its modern dome.

Though primarily designed to co-operate with the great observatories in the work of the International astrographic chart and catalogue, the photographic department of the Vatican Observatory has by no means limited its activities to mere routine work, but has secured several good solar and lunar photographs in addition to its fine studies of nebulæ and star clusters, while a speciality has been made of cloud photography, the Vatican being well represented in this department at the Royal Meteorological Society's Exhibition, held in London in 1890, for the application of photography to meteorology.*

Under Denza, who worked assiduously at his post as director until his death in December, 1894, the Vatican Observatory rose to renewed life and activity, and, conjointly with its sister establishment in Sicily, Catania, entered with enthusiasm upon its share of that great international undertaking which was to bequeath to future times a photographic record of the entire heavens at the close of the nineteenth century. It was, however, reserved for Denza's successor to the directorship, Father Rodriguez, to whose kindness and courtesy I am indebted for many of the above details, as well as for the accompanying photographs, to see this monumental work (which requires some eleven thousand plates in order to cover the whole sky) brought, after several minor interruptions, to its present more or less completed condition.

* Reproductions of some of the Observatory's cloud photographs appeared in KNOWLEDGE for May, 1899.

MICROSCOPY

Conducted by M. I. CROSS.

THE COLLECTION, EXAMINATION, AND PRESERVATION OF MITES FOUND IN FRESH WATER (*Hydrachnidæ*).

By CHAS. D. SOAR, F.R.M.S.

ANYONE with a love for natural history wishing for a hobby for his spare time, would find the study of fresh-water mites (*Hydrachnidæ*) an extremely interesting one. For variety and beauty in colour, and for differences in form and structure, they are not to be surpassed by any other organisms found in fresh water. Wherever there is a pond, ditch, or stream, the collector is nearly sure of being rewarded for his search by finding one or more species of these interesting creatures. They are easily caught, and can be seen with the naked eye; they are, however, very seldom recognised without the aid of the microscope. They can be kept alive for a considerable period at home, and are easily preserved when killed.

At present the life-history of these little creatures is so imperfectly known that there is wide scope for an observant naturalist. Although the life-histories of some species have been fairly investigated, the number of such is very limited compared with the species known, and the variety of species which have been recorded in Great Britain are behind the recorded collections of Germany and elsewhere.

These creatures are caught in three distinct stages—the larval, the nymph, and the imago. In the larval stage they are very small, and only have six legs. When they first emerge from the egg they are free-swimming, but they soon become attached as parasites to some other form of Pond-life. They will often be found hanging like small red pear-shaped appendages on a great number of aquatic insects. The six legs they started life with disappear after they have become firmly attached by their mouth organs to their host, and they spend the remainder of this period of their existence without any.

This stage is succeeded by the nymph; the little creatures are then much larger and have eight legs. During this term of their existence they are free-swimming, and can be caught in the net in numbers, but it is impossible to distinguish the sexes.

In the last stage,—the adult or imago, all the structure and form are present, but many may be taken that are not fully developed. In the majority of species, the male can be distinguished from the female and the specific differences recognised; but there are some in which the sexes are so much alike that it is almost impossible to tell one from the other. In others, again, the sexes are so different—as, for instance, in the Arrhenuri—that one would be disinclined to think they could be of the same species.

The three figures are intended to convey to the beginner the three stages mentioned. Fig. 1 is the larva of *Piona nodatus* (Mull.). Fig. 2, the nymph of *Diplodontus despiciens* (Mull.), showing the ventral surface and the epimeral plates to which the eight legs are attached. Fig. 3 is the adult *Diplodontus despiciens* (Mull.), ventral surface of female.

There is another point in the adult stage to which it will be well to draw attention. When the mite has first made its

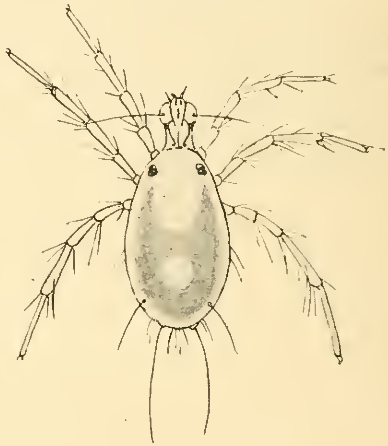


FIG. 1.

appearance from the inert period it spends between the nymph and adult stage, the hard and chitinous parts appear to be nearly fully developed, but the soft parts are not so. The body often appears very small, while the palpi, legs, and epimera, etc., are very large in proportion: it is also very poor in colour. It would be well to ascertain that the mites are quite developed before making drawings and taking measurements. In my ignorance, when I first began the study of water-mites, I had to discard a number of drawings I had made of different specimens because they afterwards proved to be only different stages of growth of the same species of mite.

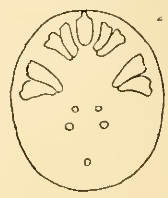


FIG. 2.

For collecting mites there is no better apparatus than the usual collecting stick used by pond hunters, having a metal ring attachable at its end which carries a cone-shaped net made of silk or muslin, with a glass tube at the bottom. The advantage of the tube is that the contents can be examined with an

ordinary pocket lens at any moment to ascertain if anything has been secured worth preserving.

It is advisable to carry as many bottles as the number of ponds that are likely to be visited; careful record should be kept of the exact locality where each mite is found, with the date of capture, and this cannot be done if all the specimens are carried home in one bottle.

The most convenient way of carrying collecting bottles is by sewing two strips of thick cloth together with loops of the required size in the same manner as a cartridge bandolier. Such

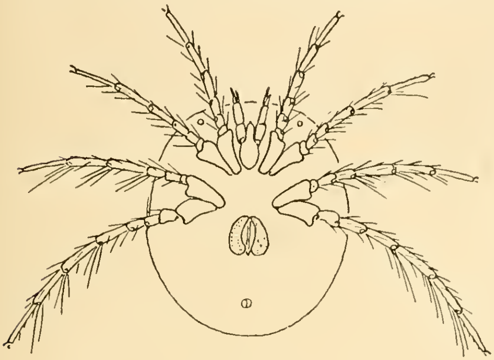


Fig. 3.

a device can be rolled and stood at the bottom of a bag, and obviates the chance of the bottles breaking by contact.

During the summer months it will generally be found that the most successful captures are made near the edges and in shallow parts of ponds; in the winter time the mites get into deeper water. Some mites are to be found only on the mud at the bottom of ponds, others on the leaves and stems of water-plants. In collecting, therefore, it is necessary to let the edge of the net just skim over the surface of the mud and sand, and up and down the stalks and stems of likely plants.

The under-surfaces of leaves should also be scraped with the edge of the net. Anacharis is a very favourite plant of water-mites, and wherever this is found it is almost certain that mites will be secured.

In addition to the free-swimming mites, there are a large number of parasitic forms, and it is as well to examine all forms of insect-life before discarding material. Fresh-water mussels, in particular, also the large water-snails and water-beetles, are specially to be recommended for examination, and, once more, let me emphasize that if anything is found, notes should be made of dates, places, and general details of the captures.

(To be continued.)

Focussing in Photo-Micrography.—There are several devices in regular use which enable the object that is to be photographed to be viewed and focussed without reference to the ground-glass screen; among these are "Beck's Observing Prism," and Mr. Andrew Pringle's device for taking instantaneous photographs, which is described in his "Practical Photo-Micrography." But it would often be an immense convenience to the worker if, after focussing the object through the microscope, he merely had to set his camera in position and make the exposure, without readjustment in the camera itself. For many classes of work this is almost a necessity, and a suggestion offered by a contributor to the *Journal of Applied Microscopy* is an excellent and practical one.

Although the difference is small between the point of visual focus when examined directly through the eyepiece and when seen upon the ground-glass screen, it can be exactly adjusted by the use of a spectacle lens. This spectacle lens has to suit the individual user, the particular objective, and camera length, but with a variety of these glasses any condition may be provided for.

The simplest way would be to fix standards by first of all focussing the object sharply upon the ground-glass screen, removing the camera, and then, looking through the microscope eyepiece in the ordinary way, interpose between it and the eye (but particularly without altering any of the focussing adjustments) several of these spectacle lenses. When the one has been found that shows the object sharply and at its best, it may be retained for the special purpose in future, *i.e.*, the next time the same objective and camera length is to be used, after the usual focussing adjustments are made with the microscope, this particular lens will be interposed and the focussing altered the slight amount necessary. The camera will then be placed in position, and there will be no occasion to refer to the ground-glass screen to verify the focussing.

This system is good so far as objects are concerned with which eyepieces are used, but aid is often more particularly required where "Planar" and long focus lenses are employed without eyepieces. It is usual to insert an eyepiece to place the best part of the object in the centre of the field, then remove the eyepiece and re-adjust upon the ground-glass screen; but the difference between the two points of focus is very great, and with considerable camera length difficulty is often experienced in reaching the microscope adjustments: a hint in this direction may therefore be of value.

When observing with the eyepiece, a plano-convex lens of a focus which will vary according to the tube length and other considerations should be inserted in the lower end of the draw-tube. The object is then focussed with this in position. For photographing, the draw-tube is entirely removed together with the viewing lens and eyepiece, and if the same method of procedure is followed in this instance as in the one previously described above, there will be no occasion to re-focus on the ground-glass screen; all that will be necessary will be to view the image sharply focussed on the ground-glass screen experimentally in the first place, then find the lens which, when placed at the lower end of the draw-tube and the object viewed through the eyepiece, will give the same image sharply focussed to the eye without altering the adjustments.

Objectives for Pond-Life Examination.—A Supplementary Note by Mr. C. F. Rousselet.—A few words on the most suitable object glasses for pond-life work may be useful to the uninitiated. It goes without saying that only the very best objectives will give permanent satisfaction. As low powers, the $1\frac{1}{2}$ in. and $\frac{2}{3}$ in. are the most useful glasses and quite sufficient for all work, the $\frac{2}{3}$ in. being, in my opinion, the highest power which can usefully, and with real advantage, be used with the binocular microscope. Then, for the study of the minuter structure of the animals, a higher power, giving a magnification of at least 300 diameters, is required. A thoroughly good $\frac{1}{4}$ in. or $\frac{1}{6}$ in. object glass will answer this purpose. Both these glasses, however, have a very short working distance, which is a source of considerable trouble when working on living and moving objects in the compressor. In practice I have found Zeiss' 12 mm. (or $\frac{1}{2}$ in.) apochromatic objective far better suited for this purpose. It has a good working distance of about $\frac{1}{8}$th of an inch, and yields a most perfect image with the various compensating eyepieces, ranging from 84 to 378 diameters. This will cover most of the work the amateur is likely to do; but occasionally, for exceedingly minute anatomical details, an object glass of greater numerical aperture will be required, for which I recommend a $\frac{1}{8}$ in. or $\frac{1}{10}$ in. apochromatic water-immersion lens.

NOTES AND QUERIES.

G. Dumant.—I quite understand your difficulty, but it is practically impossible to obtain the light from one "spot" if an incandescent filament is used. I am afraid you will have to sacrifice the ideal in this respect. An incandescent bulb could be quite simply mounted on a vertical standard to do what you require, and very good results could be secured.

NOTES ON COMETS AND METEORS.

By W. F. Denning, F.R.A.S.

Borrelly's Comet formed a fairly conspicuous object in July, passing successively through Cygnus, Draco, and Ursa Major, but it has now approached too near to the sun for observation. Even

at the time of full moon on July 9 it continued visible to the naked eye, and seemed decidedly brighter, on the whole, than Perrine's comet of September and October, 1902. On July 19, as viewed in a field-glass, the comet had a tail about 2 degrees long, directed southwards, but it was difficult to assign exact limits owing to the faintness of the outer portions. It is rarely that the apparent paths of comets are placed so favourably in the sky for observational purposes as were those of Perrine and Borrelly, for the great majority of these visitors in their flights to and from the sun are not far above the horizon, and more or less involved in twilight and obscuring vapours. The two bodies alluded to passed, however, near the zenith, and being visible to the unaided eye could be readily followed through extensive ranges of the firmament. But it is to be remarked that while Perrine's comet of 1902 attracted a large amount of attention, the present object, though equally deserving, received comparatively little notice. In the case of the former, however, special comments were made in the newspapers soon after its discovery, and the probabilities of its developing into a comet of the largest class were exaggerated. Needless to say, the public expected much and saw practically nothing. Thus the present visitor has failed to excite much enthusiasm, for a good many people, having looked in vain for certain previous comets as well as for November meteors, are inclined to regard promised celestial apparitions as rather mythical in view of several past disappointing experiences.

Borrelly's comet has been very fully investigated at the Lick Observatory (Bulletin 47). Besides the observations for position, the spectrum has been carefully studied, and several photographs, both of the comet and its spectrum, have been secured. The spectrum consisted of the characteristic cometary bands, due to carbon or some of its compounds, and it may be worth while to mention that the three bands in the visible spectrum were easily seen by Mr. Fowler and others with a small slit spectroscope attached to a 3-inch refractor. Photographs taken before July 14th show two tails, one long, straight, and narrow, and the other of about one-third the length, and greatly curved, the latter being the brighter. On the last two days of June the longer tail was split into two branches, but on the day following it was again sharp and single. On July 14th the straight tail, extending over $8\frac{1}{2}$ degrees, alone appears, widening out slightly as it extends away from the head. Throughout the period of observation, the straight tail was directed almost exactly away from the sun, and the nucleus was always sharply defined.

PERIODICAL COMETS.—Though seven of these interesting objects are due to return to perihelion this year, not one of them has been detected at the time of writing. The following is the complete list of the expected reappearances :—

Comet.	Probable Date of Perihelion. 1903.	Period of Revolution.
Tempel-Swift ...	January ...	5·547 years.
Brooks (1886 IV.) ...	March 25 ...	5·595 ,,
Perrine (1896 VII.)	April 27 ...	6·441 ,,
Faye	June 3 ...	7·488 ,,
Giacobini (1896 V.)	June 22 ...	6·647 ,,
Spitaler (1891 II.) ...	August 1 ...	6·378 ,,
Brooks (1889 V.) ...	December 11 ...	7·097 ,,

The failure to re-observe these objects is doubtless to be attributed in several cases to their unfavourable positions, but the number of large telescopes more or less employed in cometary work would lead us to expect more successes in this field. It should be remembered, however, that these comets are not only small, but that they are subject to physical changes inducing great variation in their luminosity. Holmes's comet was perceptible to the naked eye in 1892, but at its next return was visibly reduced to the 15th magnitude, and could only be distinguished in two telescopes, viz., the Yerkes 40-inch and the Lick 36-inch refractor. It is probable that some of these periodical comets are undergoing a process of disintegration similar to that which affected Biela's comet, and that in time many of them will lose their distinctive characters as cometary bodies, and be resolved into distended meteoric streams, only visible from our planet under the form of shooting stars. The two short-period comets of D'Arrest and Pons-Winnecke are due in January, 1904, but the circumstances attending their return are not favourable, and they are both likely to escape observation.

JULY METEORS.—The weather during the latter part of July was very unsettled, with much rain and cloud, so that few meteoric observations could be obtained. The writer, at Bristol, watched on July 24 for $1\frac{3}{4}$ hours, and saw 20 meteors, while on July 26 a 2 hours' watch yielded 20 meteors. The oncoming of the great Perseid shower was distinctly evident on July 24, though only three of its meteors were seen. Two of these were pretty bright, and appeared within 2 minutes of each other at 11h. 27m. and 11h. 29m. It is often the case that a pair of meteors from one and the same system make their apparitions within a short interval of time, and the inference is that the two bodies formed portions of what was originally one mass. Large individual meteors are probably often broken up by disturbances affecting them during their revolutions, and may be resolved into a number of small meteors moving in nearly concentric orbits. The writer has occasionally recorded, within a few seconds of each other, three meteors from a radiant which has given no further manifestation of activity during a watch of several hours' duration. On July 26 two or three small Perseids were seen, but the shower had apparently gained no strength since July 24. The principal radiant seemed to be near β Pegasi at $348° + 25°$. No Aquarids were observed. The most remarkable meteor recorded on the two nights appeared on July 26 at 12h. 45m. It moved with extreme slowness from $6\frac{1}{2}° + 27°$ to $16° + 14°$ in about $3\frac{3}{4}$ seconds, and came almost to a standstill at the end of its path. It had a dull reddish nucleus, and was directed from a radiant a long way back on its line of flight at $233° + 38°$ near ζ Coronæ. The same meteor was well observed by Prof. A. S. Herschel at Slough, who gives the path as $291° + 31°$ to $310\frac{1}{2}° + 22°$, and by Mr. A. King at Leicester, who recorded it as $315° - 13°$ to $323\frac{1}{4}° - 19\frac{1}{2}°$. Prof. Herschel describes the colour as yellow, then reddish-orange, and estimated the duration of flight as $3\frac{1}{2}$ to 4 seconds. Mr. King says the tint was deep orange, and duration $2\frac{1}{4}$ seconds. The meteor passed over the northern district of Hampshire, and fell from a height of 51 to 39 miles, along a path of 21 miles, with a velocity of $6\frac{1}{2}$ miles per second. Atmospheric resistance had probably much reduced its original speed, and could the luminous career of the meteor have been prolonged until much nearer the earth's surface, a further "slowing up" would have become obvious.

A bright meteor, belonging to the α Andromedids of July, was observed by Prof. Herschel at Slough, and by the writer at Bristol, on July 26, 12h. 35m. It was seen nearly in the zenith of Slough, and here it appeared as bright as Sirius. The radiant was at $1° + 27°$, and height 66 to 46 miles, from Harrow to High Wycombe. Length of path 29 miles, and velocity 53 miles per second.

LARGE METEORS.—On July 1, at about 10h. 25m., a meteor brighter than Venus was seen by Mr. T. H. Astbury, of Wallingford, Berks, passing from $318° + 32\frac{1}{2}°$ to $328° + 26°$. It left a white streak, enduring several seconds.

On July 30th, 11h. 40m., a magnificent meteor, "the size of a man's fist," was observed near Bishop's Stortford, high in the S.S.W., and passing towards S. It left a long train, and illuminated the landscape vividly. At Seaton, East Devon, the same meteor was seen in the N.E., and gave a brilliant flash. It travelled in a S.E. direction, and left a long trail of fire. It was also observed at Yarnscombe by several people, who were startled at the sudden outburst of light, and at first mistook it for lightning.

THE FACE OF THE SKY FOR SEPTEMBER.

By W. SHACKLETON, F.R.A.S.

THE SUN.—On the 1st the sun rises at 5.12 and sets at 6.48; on the 30th he rises at 5.58 and sets at 5.42.

The equation of time is negligible on the 2nd; this date, therefore, is suitable for the ready adjustment of sundials, etc.

The Zodiacal Light is prominent in the east, just before sunrise.

Autumn commences on the 24th, when the sun enters the sign of Libra at 6 A.M.

There is a total eclipse of the sun on the 21st, but only visible from the Antarctic area (*see* KNOWLEDGE, p. 121, vol. XXIV., 1901).

Sunspots and faculæ have been prevalent of late; at the time of writing there are three groups of spots on the solar disc.

THE MOON:—

	Phases.	H. M.
Sept. 7	○ Full Moon	0 20 A.M.
,, 14	☾ Last Quarter	1 14 P.M.
,, 21	● New Moon	4 31 A.M.
,, 28	☽ First Quarter	1 9 P.M.

The moon is in apogee on the 3rd and 30th, and in perigee on the 19th.

Occultations :—

			H. M.
3 Sept.	B.A.C. 7063	(Mag. 6·2) at	7 4 P.M.
11 ,,	D.M. +12° 436	(Mag. 5·9) at	11 53 P.M.
13 ,,	B.A.C. 1526	(Mag. 5·8) at	11 56 P.M.

The Planets.—Mercury is an evening star in Virgo. On the 7th he is at greatest easterly elongation of 27° E., on which date he sets about 7 P.M. He is, however, not well placed for observing, but on the day of greatest elongation he has practically the same R.A. as γ Virginis, and is 6° to the south ; this may be of some assistance in locating him.

Venus is unobservable, being in inferior conjunction with the sun on the 17th.

Mars is still visible in the south-west for a short time after sunset, but on account of his small altitude and his feeble luminosity, due to his increased distance from the earth, he is unsuitable for observation.

Jupiter is now becoming a brilliant object in the evening sky looking towards the S.E. He is in opposition to the sun on the 12th, when he attains his greatest apparent diameter, being then nearest the earth ; on this date the polar and equatorial diameters are respectively 47″·1 and 50″·4.

The most interesting satellite phenomena visible before midnight are as follow :—

Date.	Satellite.	Phenomenon.	Time. P.M.	Date.	Satellite.	Phenomenon.	Time. P.M.
Sept			h. m.	Sept.			h m.
1	I.	Tr. I.	8 16	21	III.	Sh. I.	8 10
,,	I.	Sh. E.	10 17	,,	III.	Tr. E.	10 22
,,	II.	Sh. I.	10 23	,,	III.	Sh. F.	11 26
,,	I.	Tr. E.	10 33	23	I.	Oc. D.	10 43
,,	II.	Tr. I.	10 59	24	I.	Tr. I.	7 52
3	II.	Oc. R.	8 0	,,	I.	Sh. I.	8 11
,,	III.	Ec. D.	10 13	,,	I.	Tr. E.	10 9
8	I.	Sh. I.	9 53	,,	I.	Sh. E.	10 29
,,	I.	Tr. I.	9 59	,,	II.	Oc. D.	11 59
9	I.	Oc. R.	9 32	25	I.	Ec. R.	7 45
10	II.	Oc. R.	10 13	26	II.	Sh. I.	7 37
15	I.	Tr. I.	11 42	,,	II.	Tr. E.	9 34
,,	I.	Sh. I.	11 48	,,	II.	Sh. E.	10 21
16	I.	Oc. D.	8 59	27	IV.	Tr. I.	7 55
,,	I.	Ec. R.	11 22	,,	IV.	Tr. E.	11 2
17	I.	Tr. E.	8 25	,,	IV.	Sh. I.	11 34
,,	I.	Sh. E.	8 34	28	III.	Tr. I.	10 30
,,	II.	Oc. D.	9 46				

Ec. = Eclipse. Tr. = Transit. Oc. = Occultation. Sh. = Shadow.
E. = Egress. I. = Ingress. D. = Disappears. R. = Reappears.

Saturn is rather low down in the sky, but otherwise is very favourably situated for easy observation in the evening; he is on the meridian at 9.45 P.M. on the 1st, and at 7.45 P.M. on the 30th, having an altitude of about 20°. The apparent polar diameter of the ball is 16″·6, whilst the outer major and minor axes of the ring have diameters of 41″·8 and 14″·4 respectively.

The ring is beautifully open, the ring plane being inclined at an angle of 20° to our line of vision, and we are looking on the northern surface.

Uranus is too low in the south-west to be easily observable.

Neptune is not in convenient position for observing until near midnight.

The Stars.—At the beginning of the month, at 9 P.M., the following constellations are to be observed :—

Zenith . Lyra, Cygnus.

South . Aquila, Delphinus, Aquarius, Capricornus, Sagittarius ; Serpens, Ophiuchus, and Scorpio, to the S.W.

East . Andromeda, Pegasus, Pisces, and Aries ; Pleiades on horizon.

West . Hercules, Corona, Boötes.

North . Ursa Major, Ursa Minor ; N.E., Cassiopeia and Perseus ; Auriga (*Capella*) on horizon.

Minima of Algol occur on the 3rd at 0.37 A.M., 5th at 9.26 P.M., 25th at 11 9 P.M., 28th at 7.58 P.M.

Chess Column.

By C. D. Locock, B.A.

Communications for this column should be addressed to C. D. Locock, Netherfield, Camberley, and be posted by the 10th of each month.

Solutions of August Problems.

No. 1 (W. Geary).

1. Q to Ktsq., and mates next move.

No. 2 (A. Lillie).

[The author's key is 1. Q to R8, but there are several other solutions, *e.g.*, 1. Q to B4ch, 1. K to Kt7, 1. R to B7.]

Solutions received from "Alpha," 2, 6; W. Nash, 2, 6; G. A. Forde (Major), 2, 4; "Looker-on," 2, 6; W. H. S. M., 2, 6; G. W. Middleton, 2, 6; "Quidam," 2, 6; C. Johnston, 2, 6; H. F. Culmer, 2, 4; T. Dale, 2, 6; E. A. Servante, 2, 4; J. W. Dixon, 2, 6; A. C. Challenger (too late to count points).

"Quidam" has written to say that he sent in solutions of the May problems under his real name instead of his usual pseudonym. Hence the fact that he was not credited with points for them. The solutions were perfectly correct, and 6 points must accordingly be added to "Quidam's" score as published in the July number.

C. V. Howard.—Correct, but nearly a fortnight too late.

W. H. S. M.—Your postcard of June 27th postmark for some reason took three weeks to reach me, arriving just in time for a special correction after proofs. Your letter of August 10th (insufficiently stamped, by the way) contains solutions of July problems.

E. A. Servante.—The problems shall be examined. Could you not use more conventional diagrams?

PROBLEMS.

No. 1

By H. N. Fellows (Wolverhampton).

Black (4).

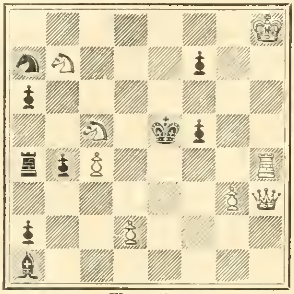
White (9).

White mates in two moves.

No. 2.

By B. G. Laws.

Black (9).



White (8)

White mates in three moves.

CHESS INTELLIGENCE.

The North *v.* South Correspondence Match has again been won by the South, but the margin of victory is much less decisive than on the last occasion. The final score was—South, 138; North, 114. On the Northern side the Lancashire and Cumberland players proved to be the most successful. The prizes offered for the best games were awarded to Mr. F. P. Carr, South (No. 8), and Mr. H. Doyle, North (No. 17).

Mr. Lasker, as might have been expected, has declined to accept the terms suggested by Mr. Marshall for a championship match. A match between Messrs. Lasker and Pillsbury seems a much more likely event, and would certainly arouse more interest.

Game played in the recent "King's Gambit" Tourney at Vienna.

"Muzio Gambit."

White.	Black.
G. Maroczy.	M. Tchigorin.
1. P to K4	1. P to K4
2. P to KB4	2. P takes P
3. Kt to KB3	3. P to KKt4
4. B to B4	4. P to Kt5
5. Kt to B3 (*a*)	5. P takes Kt
6. Q takes P	6. P to Q3
7. P to Q4	7. B to K3
8. Kt to Q5 (*b*)	8. P to QB3
9. Castles	9. P takes Kt
10. P takes P	10. B to B4
11. B takes P	11. B to Kt3
12. B to Kt5ch	12. Kt to Q2
13. QR to Ksqch	13. B to K2
14. B takes P	14. K to Bsq (*c*)
15. R takes B!	15. Kt takes R
16. R to Ksq	16. K to Kt2 (*d*)
17. B takes KKt	17. Q to R4
18. Q to K2	18. Kt to Bsq (*e*)
19. B to B6ch	19. K to Ktsq
20. Q to K5	20. P to KR3
21. B takes R	21. P to B3
22. Q to K7	22. K takes B (*f*)
23. Q takes Pch	23. Resigns.

Notes.

(*a*) The modern fashion, instead of 5. Castles, which used to be almost the invariable procedure. The text move has the advantage of forestalling the defence 7. . . . Q to B3, threatening Q to Q5ch if White had Castled.

(*b*) A very remarkable move, necessitating, presumably of set purpose, the sacrifice of another piece.

(*c*) 14. . . . Q to Kt3 certainly seems preferable. If then 15. Q to QR3, as suggested by the *Yorkshire Post*, Black could Castle on the Queen's side with apparent safety, before or after checking, without losing more than one of the pieces gained. The move made gives Herr Maroczy the opportunity for further brilliancy.

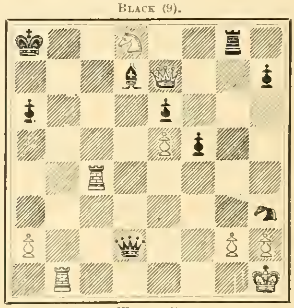
(*d*) Probably K to Ktsq would be better, in view of the colour of the diagonal occupied by the more prominent White Bishop.

(*e*) If 18. . . . QR to Qsq, 19. B × Kt, R × B; 20. B to B6ch, K to Bsq; 21. Q to K3 wins.

(*f*) If 22. . . . B to B2, 23. R to K3, Kt to Kt3; 24. R to KKt3, etc.

A correspondent sends the following very instructive ending of a game recently played:—

Black (9).



White (9).

White mates in four moves.

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CONTENTS.

RADIUM.

By Edwin Edser, A.R.C.Sc., F.Ph.S.

Many and various are the effects, apparent in the present aspect of science, which may be traced to Prof. Röntgen's classical discovery of "X-Rays" in 1895; of these, not the least important is the sustained interest manifested in connection with all problems relating to radiation. To this interest must be ascribed the brilliant series of researches which have culminated, for the time being, in the discovery of a new element, Radium; an element possessing properties so far removed from those generally imputed to matter, that many of our accepted scientific theories are found to require reconsideration, while some must be profoundly modified or even abandoned. A characteristic continually recurring in these researches is the unexpectedness of the results achieved; over and over again an experimenter, when seeking for some effect which might rationally have been anticipated, has come across a phenomenon which may fairly be said to have transcended all previous knowledge.

A beginning was made in 1896 by M. Henry, who showed that phosphorescent sulphide of zinc emits radiations which can penetrate black paper, and affect a photographic plate. About the same time M. Niewenglowski found that sulphide of calcium, rendered phosphorescent by exposure to sunlight, emits radiations which can penetrate a thin sheet of aluminium. Unlike X-rays, these radiations are refracted by glass; they apparently constitute an intermediate link between ordinary ultra-violet light and X-rays. M. Henri Becquerel followed up these researches by placing various phosphorescent substances above photographic plates shielded from light by layers of black paper or aluminium. On one occasion a plate was enclosed in black paper, on the outside surface of which a quantity of the double sulphate of uranium and potassium was sprinkled. It had been intended to expose this arrangement to sunlight in order to provoke phosphorescence in the uranium salt, but the weather proving inclement, the prepared plate was placed just as it was in a drawer, where it was left for several days. By a lucky chance it was afterwards decided to develop this plate; on doing so, it was found that it had been affected by some form of radiation emitted by the uranium salt, although the latter, having remained unexposed to sunlight, had produced no visible phosphorescence. Subsequent experiments showed that the uranium salt apparently possessed the property of continually emitting radiations, which, though invisible to the eye, could traverse paper, wood, or aluminium, and subsequently decompose silver salts. It was found that this property persisted, without any discernible falling off, after three years, during the whole of which time the active substance was enclosed in a leaden box with double walls. These radiations were termed "Becquerel rays," in honour of their discoverer. It was at first thought that they were extinguished by crossed tourmalines, in which case we should have had to conclude that they were polarizable, and therefore essentially transverse ether vibrations resembling ordinary light, but differing from it, in all probability, in having a much smaller wave-length. Subsequent experiments proved, however, that there was no conclusive evidence of polarization.

Becquerel's discovery excited considerable attention, and much surprise was naturally evinced that any substance should be capable of continually emitting energy without showing signs of ultimate exhaustion. Had we at last found a case to which the law of conservation of energy did not apply? Could we be said to have found an inexhaustible source of energy? These questions were frequently asked. But to be fruitful, such questions must be submitted to nature, and not merely propounded in newspapers or the pages of a scientific periodical. Among those who felt themselves impelled to seek further experimental evidence on this interesting topic must be mentioned M. Pierre Curie and Mme. Sklodowska Curie. To understand the advance these investigators effected, it must be mentioned that the radiations emitted by uranium salts are very feeble, requiring many hours even to affect a photographic plate. The metal uranium was discovered in 1789 by the German chemist Klaproth; it has an atomic weight of 239, and occurs in various minerals, notably "uraninite" or "pitchblende," which is a mineral containing about 81·5 per cent. of uranium, 4 per cent. of lead, and 0·5 per cent. of iron, with oxygen, water, and various impurities. It occurred to Mme. Curie to test the radio-activity of the residue obtained after removing the uranium from pitchblende. To her surprise, she found that the radio-activity of the residue was far greater than that of the separated uranium salt. The radio-activity observed by Becquerel was thus proved to be due to some hitherto unknown substance or substances occurring in

pitchblende, traces of which are carried down with the separated uranium salt, and remain with it as an impurity. Now commenced a long, arduous, and painstaking attempt to discover the nature of these substances. Anyone who has attempted to analyse exhaustively a mineral for *known* substances answering to *known* chemical reaction can form some faint idea of the difficulty which the Curies met, and surmounted, in their attempt to isolate the radio-active agent in pitchblende, without any previous knowledge of its chemical properties. First of all, a radio-active substance was separated, which was about 300 times as active as the salts examined by Becquerel. This substance, which resembles bismuth in its chemical behaviour, was termed *polonium* by Mme. Curie, in honour of Poland, her native land. Later on, M. and Mme. Curie, together with M. Bemont, isolated a second substance, which was termed *radium*. In 1899 a third substance, which is closely associated with thorium, was isolated; this substance has been termed *actinium*. Of these three substances, radium alone has been isolated in a state of purity sufficient to determine its essential properties. It has not been obtained in the form of a metal, but only in that of a salt, such as a bromide, chloride, or nitrate. There appears to be no doubt as to its being a true element; M. Curie has gone so far as to determine its atomic weight, which is found to be 225. It also has a definite spectrum. The best samples of radium obtained by the Curie are 1,000,000 times as active as the uranium salts originally examined by Becquerel. To understand the difficulty of obtaining an appreciable amount of radium, it must be remembered that as a preliminary step uranium must be removed from the pitchblende; in order to obtain one kilogram (2·2 lbs.) of radium, it would be necessary to treat 5000 tons of the uranium residues! After this we can hardly wonder that radium bromide costs about £1250 per gramme. As Prof. J. J. Thomson has said, it is more easy to isolate the gold in sea-water than to separate the radium in pitchblende.

Having obtained a substance so powerfully radio-active as radium, M. and Mme. Curie were in a position to determine the conditions attending radio-activity. In the first place it was found that an insulated charged conductor quickly loses its charge if a radio-active substance is sprinkled on it. Further, if a particle of radium is brought near a charged electroscope, the latter is quickly discharged. Now it has been known for many years that ultra-violet light, if allowed to fall on a negatively charged body, will cause a rapid discharge to occur. By a beautiful series of experiments, Prof. J. J. Thomson has shown that ultra-violet light causes small negatively charged particles to be thrown off from bodies on which it falls, and has even determined the mass of these particles, each of which possesses about one-thousandth part of the mass of an hydrogen atom. X-rays, falling on a body, cause negatively charged particles of a similar character to be thrown off. The question now arose as to whether radium rays were essentially similar to either ultra-violet rays or X-rays? If not, what was their distinguishing characteristic?

The answer to this question is derived from the circumstance that the most active portions of radium emanations are deflected when they pass at right angles across a magnetic field, while the rays of ultra-violet light, or X-rays, are undeflected under similar conditions. To explain this more fully, let us suppose that a horse-shoe magnet is laid on a photographic plate. Between the magnet poles, stretching from one to the other, are lines of magnetic force, which are said to constitute a magnetic field. These lines will lie, in the main, parallel to the plate. A ray of light, or an "X-ray," incident normally on the plate between the poles of the magnet, will be at right angles to the lines of force. Now, if such a ray is deflected by the magnetic field, the plate, when developed, will exhibit a dark spot at a position different from that which would be produced if the magnet had been absent. In another arrangement, the ray may be allowed to fall on the plate, first, with the magnet absent, and then, without altering anything else, with a magnet placed so that the ray passes between its poles. If the ray is deflected by the magnetic field, we shall obtain *two* spots on the developed plate, one due to the deflected, and the other to the undeflected ray. Such deflection has never been observed with relation to X-rays or light rays, and this fortifies us in our belief that X-rays are merely ultra-violet rays of extremely short wave-length. On the other hand, if a particle of radium is placed above a photographic plate, from which it is separated by a sheet of black paper or aluminium, a diffused spot on the developed plate will show the position where the radium rays struck it. The position of this spot differs when a magnet is laid on the plate so that the rays pass between its poles, and when the magnet is absent; thus radium rays are distinguished from X-rays, or light rays, by their capacity to be deflected in a magnetic field.

It is well known that a conductor traversed by an electrical current will be acted on by a force tending to displace it if it is placed at right angles to the lines of force of a magnetic field; a practical application of this law has given us the electric motor. It is further generally admitted that a series of electrically charged particles moving along a straight line acts in many respects like an electrical conductor carrying a current. In other words, if we imagine electrified particles to be projected with great velocity along a given straight line, the path of these particles may remain strictly rectilinear if they nowhere cross the lines of force of a magnetic field; but if, anywhere in their course, they pass between the poles of a strong magnet, their path will there be deflected, and will subsequently be inclined to its original direction. Such a stream of particles would therefore strike different points of a target, according as it passed between the poles of a magnet, or travelled through space free from a magnetic field. These phenomena are so exactly parallel to those observed in connection with radium, that there is little doubt left that radium emanations consist mainly of charged particles shot off from the active substance.

Up to the present, radium rays have been spoken of as if they were all of one kind. They all, indeed, possess properties which are to a certain extent similar; but experiments enables us to distinguish between at least three kinds of rays. It is found that a great part of the rays emitted by radium are intercepted by a thin screen of aluminium. Those which have passed through this screen can traverse a much thicker screen of the same substance without further loss; in other words, the rays have been sifted of those which are only slightly penetrative (termed the α rays), while those which possess greater penetrative capacity (termed the β rays) have been left. Both the α and β rays are deflected in a magnetic field, though to different extents; both discharge electrified conductors on which they fall. The α rays, when allowed to fall on a negatively charged conductor, discharge it with great rapidity; they therefore carry a positive electric charge. The more penetrative β rays discharge a positively charged conductor fairly well; they therefore carry a negative charge. In a magnetic field the α rays are deflected to a smaller extent than the β rays; indeed, it is only quite recently that Prof. Rutherford, using a very strong magnetic field, has succeeded at all in deflecting the α rays. Taken in conjunction with the facts previously dwelt on, this leads to the conclusion that the α rays are positively

charged particles of the dimensions of an ordinary atom, moving with a fairly small velocity; Prof. Rutherford estimates that their velocity is about $2{\cdot}5 \times 10^9$ cms. per second. The high penetrative capacity of the β rays leads to the conclusion that they consist of streams of excessively small negatively charged particles moving with a very great velocity; they are probably identical with those discovered by Prof. J. J. Thomson, each possessing a mass equal to about a one-thousandth part of the mass of a hydrogen atom; their velocity is probably comparable with that of light.

In addition to the α and β rays, radium emits a small quantity of very highly penetrative rays, termed the γ rays. These can penetrate a considerable thickness of aluminium, and are not deflected in a magnetic field; it is now generally held that they are closely related to, if not identical with, X-rays.

An important step has lately been achieved by Prof. Rutherford and Mr. Soddy. These experimenters caused air to bubble slowly through water in which a small trace of a thorium salt was dissolved, after which it was led through a lead tube into the case of a charged electroscope. The charge of the electroscope was seen to rapidly diminish, showing that the air carried charged particles away from the radio-active solution Part of the lead tube through which the air passed was coiled into a spiral, and this was next placed in a jacketing vessel containing liquid air. On re-charging the electroscope, it was found that the charge scarcely diminished. From this it was concluded that the charged particles which had previously been carried into the electroscope had become condensed in passing through the cooling spiral.

Struck by the results just described, Sir William Ramsay conceived the brilliant idea that the substance condensed in the cooling worm was a gas. To test this point, a small quantity of radium was placed in an exhausted vessel communicating with a bulb immersed in liquid hydrogen. After some months the substance condensed in the bulb was pumped into a vacuum tube, when a spectroscopic examination showed that this substance was helium! From this the conclusion is drawn, that the α rays consist of streams of charged helium atoms.

Where has this helium come from? There is no reason to suppose that helium was present, *as helium*, in the radium salt; our only alternative is to suppose that the element radium possesses the unique property of spontaneously decomposing into other elements, one of which is helium! In this connection it should be noted that the high atomic weight of radium indicates that the atoms are of a complicated structure; perhaps it may be found ultimately that the elements of high atomic weight, at one end of the Mendelaef series, are capable of spontaneous transmutation into the elements at the other end of the series.

Is, then, the dream of the alchemists about to be realized? It would appear so, at any rate in part; but in place of other substances being transmutable into gold, it would appear more probable that gold (an element of fairly high atomic weight) may be capable of transmutation into helium or other gases.

When radium is placed in the dark, it phosphoresces spontaneously for an indefinitely long period. Sir William and Lady Huggins have examined the spectrum of the light thus emitted, and find that after several days' exposure, a photograph plate shows a number of definite lines, some of which correspond to lines in the spectrum of helium. This result confirms the conclusions arrived at by Sir William Ramsay.

Before the above results had been obtained, Prof. Curie had found that a fragment of radium, when placed in an isothermal enclosure, maintains itself constantly at a temperature about $1{\cdot}5^\circ$ C. above its surroundings. A gram of radium, in one hour, emits about 100 gram-calories of heat, and could, therefore, continue indefinitely to melt more than its own weight of ice per hour.

To what extent can we now form a scheme of explanation of this phenomenon? At present the highest authorities would mostly subscribe to the following theory. The complicated radium atom is continually breaking down into the atoms of simple elements, of which one is helium. In this process a large amount of energy is liberated by the decomposition of each radium atom; thus the helium atoms are flung off with a great velocity, and, therefore, possess much kinetic energy, and in the interior of the radium this energy is transformed, during collisions, into heat. At the outside of the radium the helium atoms escape, carrying positive charges, and constitute the α rays. Sir William Crookes has invented an instrument termed the spinthariscope, by the aid of which this escape can be observed. A particle of radium is placed in front of a fluorescent screen, and the latter is examined by means of a lens; small luminous points continually flash out on the screen and gradually die away, indicating the points struck by the escaping particles.

Minute negatively charged particles or electrons are also thrown off during the above process, and these constitute the β rays. The latter particles striking on the radium itself, or surrounding objects, give rise to feeble X-rays, just as the cathode stream in a vacuum tube excites X-rays in objects on which it falls; this accounts for the γ rays. The greatest outstanding mystery is encountered when we try to explain why the radium atom decomposes. If decompositions are due to collisions, it might be supposed that a considerable moleculous velocity, which is equivalent to a fairly high temperature, would be necessary; but Prof. Dewar has found that radium, even when surrounded by liquid hydrogen, still emits radiations which can discharge an electroscope, and which presumably constitute β and γ rays. The rate at which decomposition progresses is extremely slow. Prof. Rutherford estimates that in a year a gram of radium emits about $0{\cdot}21$ c.c. of helium, and this would correspond to a loss of weight of less than a tenth of a milligram. No conclusive evidence of any loss of weight has so far been observed.

In conclusion, attention may be drawn to the physiological effects of radium emanations. If a small fragment of radium, sealed up in a glass tube, is carried for a few hours in a waistcoat pocket, the skin nearest to the radium is afterwards found to be blistered. It appears that radium emanations destroy all living tissue; they have also been found to be bactericidal. Prof. Curie states, that he would be afraid to enter a room containing a pound of radium; he anticipates that, if he did so, his skin would be blistered, his eyesight destroyed, and probably death would ultimately occur. Feeble radium emanations may, however, in the near future be found to possess valuable therapeutic properties. Thus Prof. Rutherford suggests that the inhalation of air which has bubbled through a dilute solution of thorium, might prove valuable in the treatment of consumption. X-rays have been found to cure superficial cancers; they probably do this by destroying the cancerous tissue. In the treatment of deep-seated cancer, X-rays cannot be used; they are necessarily applied from the outside, and would have to destroy the healthy external tissues before they could reach the cancer. It has, however, been suggested that a small sealed tube containing radium might be introduced into the midst of an internal cancer, and thus destroy the latter without affecting the healthy tissues Prof. J. J. Thomson has found that many well-waters are radio-active, and since the Bath waters have been found, by Sir William Ramsay,

to contain helium, it is possible that these are radio-active also, and to this their efficacy may be due. It is generally understood that the Bath waters lose their efficacy if not taken immediately after being drawn, and this may be due to the decomposition of the small trace of radio-active substance which they presumably contain.

MAN'S PLACE IN THE UNIVERSE.

By E. Walter Maunder, F.R.A.S.

In the *Fortnightly Review* for September, 1903, Dr. Alfred Russel Wallace replies to the critics of his paper on "Man's Place in the Universe." The critics had attacked each and every astronomical point of his position, and now, in his reply, Dr. Wallace withdraws most of his astronomical arguments, whilst re-asserting the conclusions which he had drawn from them. His reply, therefore, though in form a defence of his original position, is in substance an unconditional surrender of it.

It may be well to quote here Dr. Wallace's summary and conclusion of his first paper :—

> "We can hardly suppose any longer that *three* such remarkable coincidences of position and consequent physical conditions should occur in the case of the one planet, on which organic life *has* been developed, without any causal connection with that development. The three startling facts—that we *are* in the centre of a cluster of suns, and that that cluster *is* situated not only precisely in the *plane* of the Galaxy, but also *centrally* in that plane, can hardly now be looked upon as chance coincidences without any significance in relation to the culminating fact that the planet so situated *has* developed humanity.
>
> "Of course the relation here pointed out *may* be a true relation of cause and effect, and yet have arisen as the result of one in a thousand million chances occurring during almost infinite time. But, on the other hand, those thinkers may be right, who, holding that the universe is a manifestation of Mind, and that the orderly development of Living Souls supplies an adequate reason why such an universe should have been called into existence, believe that we ourselves are its sole and sufficient result, and that nowhere else than near the central position in the universe which we occupy, could that result have been attained."

Now if we assume that these words imply what their sense may be taken to indicate, we infer that Dr. Wallace means that:—

(1) The Galaxy with its appendages and included systems, to all intents and purposes makes up the entire material universe.

(2) The earth in its character of a satellite of the sun is situated *centrally* in the *plane* of the Galactic ring, and the physical conditions necessary to life are only possible in such a central position.

On the first point Dr. Wallace's withdrawal from his former position is sufficiently definite. He writes :—

> "Is the evidence at our command for or against the infinite extension of the stellar universe ? This is the real question, the only question we are able to discuss rationally. As to proof or disproof, either is impossible as regards what exists, or what does not exist in infinite space. And even as regards the probability of any particular form of existence being infinite, we have, and can have, no evidence, and without evidence it is irrational to hold any definite opinion."

With this position astronomers cannot quarrel ; it is indeed the very point for which Dr. Wallace's critics were contending. But it cuts away the ground from the arguments of his first paper; he then claimed to have demonstrated that which he now admits to be incapable of proof. It is true that in the next sentence he re-asserts his claim to have brought forward "sufficient evidence" of the limitation of our stellar universe, but before the end of the next paragraph he seems to have come to the conclusion that since his position cannot be demonstrated, it ought not to be challenged, and he refers to objections as "the opinions or prejudices of those who ask for proofs of what cannot be proved." Dr. Wallace makes several quotations to show that astronomers of repute have arrived at the conclusion that the stellar universe is limited in extent, and complains that directly he, an outsider, ventures to set forth the same view, he is found fault with.

There has been no dead set made upon Dr. Wallace because he is an outsider. Some three years before the appearance of his first paper in the *Fortnightly Review* there was an interesting discussion in Knowledge on the question "Is the stellar universe finite?" which I concluded by the following words :—

> "The general question 'Is the Stellar Universe finite ?' becomes at once not a physical but a metaphysical enquiry, and hence leaves the domain of astronomy, and except as a purely mental exercise I see no value in it. How easily even the keenest and most trained minds may go astray on the subject may be learned from Prof. Newcomb's paper in the March number of the *Windsor Magazine*.* He writes 'it can be shown mathematically that an infinitely extended system of stars would fill the heavens with a blaze of light like that of the noonday sun.' There is a tacit assumption here that the stars are on the average uniformly distributed in space, an assumption which for nearly a century astronomers have known to be untrue."†

A similar statement by Prof. Newcomb occurring in a paper in the *Popular Science Monthly* appears to have been the basis of Dr. Wallace's original paper, but that it was a mistake, and that Prof. Newcomb did not alter his views merely in order to disagree from Dr. Wallace, may readily be seen by referring to the same paper when it was corrected and republished in book form in 1901.

Dr. Wallace yet more unreservedly withdraws his suggestion that the suns on the confines of the Milky Way are "becoming dissipated into outer space," and that "the outer margins of the stellar universe are therefore unstable," so that it "follows that the outer portions of the universe, at all events, and for an unknown extent inward, will be entirely unfitted to ensure that *continuity of uniform conditions* which is the first essential for the development of life." He now admits "that there is probably no justification for this idea, and that the facts that suggested it are *apparent* only." He also withdraws the "similar unfounded notion . . . of a variation of gravity near the boundary of the universe." But these two "unfounded notions" were his sole arguments to prove that "the continuity of uniform conditions which is the first essential for the development of life" is not possible in the case of satellites of such suns as lie within or on the confines of the ring of the Galaxy. There is left, therefore, not even a suggestion of a reason for supposing any star within the reach of our telescopes to be less stable in the conditions due to its position than is the case with our sun.

These ample concessions having been made, it would be a superfluous task to show again that Dr. Wallace had no solid grounds for asserting the centrality of our sun in his particular sense of the word. He complains that his critics misrepresent him on this point, and ascribe to him a precision of meaning which he did not intend. He prefers now to speak of the position of the sun as "nearly central." Frankly, I think his critics allowed his expressions to pass as being less stringent than they were. But a turn of expression may pass for little; it is the argument that counts. And the argument demanded that the sun should be shown to be very materially nearer the centre of the universe than any other star whatsoever. There are no facts known to astronomers which would warrant them in asserting that our sun is better placed in this sense than are hundreds of members of that hypothetical globular cluster of which he speaks.

* March, 1900. † Knowledge, 1900, May, p. 109.

Dr. Wallace brings forward some new points which are not, however, germane to the question. Several writers in objecting to his statement that if the stellar universe were infinite in extent the entire sky would be a blaze of starlight, made the very sufficient answer that the same line of argument if applied to the dark stars would lead to an opposite conclusion. The reply was amply sufficient for its purpose, but Dr. Wallace tries to answer it as if it had been brought forward, not as a mere *argumentum ad hoc*, but as an actual theory of the universe, and urges that if the dark stars were so numerous we should frequently observe occultations of the lucid stars. A very little calculation shows that even if the dark bodies were a thousand times more numerous than the bright, the chances are millions to one against any diminution of the light of a lucid star arising from this cause ever having been observed.

Another point is that though the sun is moving with prodigious speed, yet that the action of gravity would prevent it wandering far from its present position. Why should it? It has had no such action upon Arcturus, and other "runaway" stars. Then Dr. Wallace raises the question of "star-drift"; that is to say, of groups of stars moving with a common proper motion. In what way this helps his argument does not appear. The reference to the five stars of Ursa Major is a particularly unfortunate one, since this group, extending over nearly twenty degrees of arc, is obviously moving as a system in a plane which is nearly at right angles to that of the Milky Way. The latter plane, therefore, is not the only one of high importance within the limits of the visible sidereal system.

It is disappointing that Dr. Wallace takes no notice of an exceedingly suggestive point raised by Prof. H. H. Turner. We speak roughly of the Galaxy as forming a ring. The researches during the last half-century of Heis, Boeddicker, Backhouse, Stratonoff, Easton, and others, have shown us that it is about as unlike a simple annulus as any object could possibly be. It is an object of the greatest complexity, formed of long irregular branching streams, interlacing and crossing one another, and some of them reaching out far towards its poles, of close agglomerations side by side with broad lacunæ. But, most striking of all, there are two portions—if portions they be and not separate and external galaxies—which stand out by themselves and away from the main body—the two Magellanic Clouds. If they are truly part of the Galaxy, then we are no longer in a position to assert that we are in its medial plane or near the centre of that plane. If they are external galaxies, then our Galaxy is not the sole one known to us; the visible universe evidently extends much beyond it.

But if we *did* hold a "nearly central" position, Dr. Wallace's question, "What advantages have we derived from it?" would still be wholly unpractical, and to complain there are "hardly any suggestions of enlightenment in astronomical literature, but, rather, what seem to me now to be unnecessary difficulties thrown in the way of the enquirer," is much as if a man took a candle in order to read the time of night from a sundial, and complained that the literature on dialling gave no guidance how to proceed in such circumstances.

Practically, Dr. Wallace's position in his second paper amounts to this. He has withdrawn as untenable the propositions upon which his original thesis was based; but in effect he claims the right to maintain his former conclusions until his critics have demonstrated propositions, the opposite of all those he has advanced.

To sum up. We have no sufficient evidence to show whether the stellar universe has an indefinite extension or not; or, if it be bounded, whether we have yet penetrated to the boundary. Supposing such a boundary, we have not the slightest reason to suspect any star that we can see of being in an unstable condition owing to its nearness to it. We do not know whether the Galaxy includes in its structure the whole of the objects which we see, or whether any considerable number lie beyond it and are of a different formation. We do know, and it has long been known, that our sun is near the medial plane of the Galaxy, and probably not more than twice as far from one side of it as from the other. But we do not know that it is nearer the centre of the Galaxy than hundreds of other stars, nor have we the slightest reason to suppose that the systems attendant upon them are less fitted to be the home of intelligent life than our own.

THE CLAWS ON THE WINGS OF BIRDS:

A STUDY IN EVOLUTION.

By W. P. Pycraft, A.L.S., F.Z.S., etc.

It may not be generally known that, hidden away among the feathers of a bird's wing there are to be found frequently two tiny claws, one on the thumb, the other on what corresponds to the first finger of the human hand. According to the text books these are to be regarded as relics of a reptilian ancestry: mere survivals of an order of things now obsolete. Just as the gill-slits in the mammalian embryo point to a fish-like aquatic stage of development long since suppressed; or as the vestiges of haunch and thigh bones buried deep in the muscles of the belly of the whale point to a time when functional hind limbs were present.

The very best of reasons may be urged for accepting this hypothesis, inasmuch as in the most ancient, and at the same time most reptilian, of all known birds—the lizard-tailed *Archæopteryx*—as well as in the Giant Ostriches, which are admittedly primitive, these claws are very large, whilst in the most modern types they are always small, or wanting. Again, like all vestigial organs, the method of their going is slow and more or less orderly. They beat, as it were, a dignified retreat, taking their dismissal with reluctance. Thus, only in the primæval *Archæopteryx* do we find the full complement of claws, one to each of the three digits—all that remains of the hand in the bird's wing. The first to disappear was the claw on the third digit. This has now completely vanished from the adult life of living birds, and only occasionally appears in the embryo of the Old-World ostrich. Growing gradually smaller and smaller, the remaining two frequently appear only during embryonic life, and may cease, like the vanished number three, to be reproduced even here. The gradual stages in this work of demolition, so invariably associated with vestigial structures, seemed, we may repeat, the best of evidence for regarding these claws as mere survivals of a reptilian origin, and of no other significance or purpose within avian times.

The axe must, however, occasionally be laid to the roots of the most promising hypothesis, and sometimes the warrant comes from most unexpected quarters. Even from "babes and sucklings," as in the present case—to wit, the young of the aberrant South American game-bird, known as the Hoatzin. Clawless in the adult, the wing in the nestling, on the contrary, is found to be provided with claws of an unusually large size. This fact, nothing being known of the life-history of this bird, would have been interpreted as an instance of organs which had for some unknown reason resisted the decadence which had overtaken the same structures in other species, and here the matter would have rested. Fortunately, however, we are in possession of a very complete account of the habitat and breeding habits of the Hoatzin, due largely, indeed principally, to the observations of Mr. Quelch. He has

placed it on record that this bird is one of the most strictly arboreal of all known birds, never having been seen to alight on the ground. The haunt of this species being the low bushes and trees fringing river banks and lagoons of the regions watered by the Amazon.

So strictly a tree-dweller naturally, we may say indeed necessarily, establishes its nursery in the tree-tops; and herein we are brought face to face with a surprise. In all other instances, the young of birds reared in trees are hatched in a perfectly blind, naked, and helpless condition. Not so with the Hoatzin, however. The young emerge from the shell endowed with a very lively disposition, wandering about the branches of the tree in which the nest is placed, at their own sweet will.

These wanderings are necessarily attended with considerable peril, but the risk of accidents is diminished by the presence of the large claws already referred to. Grasping the boughs with enormous feet, and aided by the claws and beak, they are among the most expert of climbers at a very tender age. But the wing at this time differs in several other remarkable particulars from that of other birds, and even from that of the adult condition. Closely examined, it will be found that the hand is conspicuously longer than the forearm, and that the thumb is also unusually long. Furthermore, the undersurface of the thumb and first finger will be fonnd to resemble those of the human finger, in that they terminate in a fleshy ball, obviously useful for grasping purposes.

At this time, then, the wings serve the very un-birdlike function of forelegs, and locomotion is quadrupedal rather than bipedal, and this remains the case till the power of flight is attained. The development of flight is associated with another remarkable feature. The quills of the flight feathers, it will be remembered, grow from the whole border of the forearm and hand. Now if these quills all grew at the same rate, those of the hand would soon render climbing impossible, or at least highly dangerous, by impeding the hold of the claws, and at the same time these feathers would not be large enough to break the force of a fall, which would be fatal. Consequently in the case of the young Hoatzin, the growth of the outermost quills—those nearest the claws—is completely suspended till the innermost quills of the hand and those of the forearm immediately proximate, are sufficiently large to function at least as a parachute in the case of accidents. As soon as this has been arrived at a complete change in the form of the wing takes place. The further growth of the claws is not only arrested, but the claws themselves become absorbed, so that, in the adult, no trace thereof is left. Simultaneously the forearm commences to grow more rapidly than the hand, so that, when the bird is adult, the latter is *shorter* instead of longer than the former!

There can be little doubt but that the climbing phase in the life-history of this bird is a primitive character, carrying us back to the very dawn of avian development. It cannot be a character acquired by this species in adaptation to its peculiar mode of life, inasmuch as this would imply that the claws had been redeveloped from the vestigial condition into which they had sunk, and we know that resuscitation of this kind never takes place in nature. They must then have been handed on in unbroken descent from the very earliest birds, having remained functional throughout the whole of this time.

Fortunately, however, we have no need to depend upon the sweet reasonableness of this view for its general acceptance. Evidence is obtainable on the one hand through an appeal to the dry bones of the past, and on the other by an examination of species still living, which makes its acceptance irresistible.

We will turn first to the fossil to which reference has already been made—Archæopteryx. In this ancient bird, the wing, when carefully examined, will be found to be unmistakably that of a forest-dwelling species, inasmuch as in general contour it agrees precisely with that common to all dwellers among trees, being rounded instead of pointed in form. Birds so diverse as eagles and cuckoos, owls and game-birds, foremost among which stands the Hoatzin, when strictly forest-dwellers, or dwellers amid jungles, have wings of this type, whilst birds which fly much in the open have pointed wings. Furthermore, the wing of this fossil agrees closely with that of the young Hoatzin in that the hand is longer than the forearm, and has the top of the index finger free and armed with a claw. Only in this it differs, that whereas these proportions obtain only in the nestling Hoatzin, they were retained, together with the claws, throughout life in the fossil form. The explanation of the difference lies probably in the fact that the need for climbing was not merely confined to the nestling period, but was demanded periodically throughout life. And for this reason, like the ducks, and some other birds of to-day, *Archæopteryx* probably moulted all its quill feathers at once, and thus, till the new feathers had grown sufficiently long and strong, the bird was flightless. At this time a reversion to the locomotion of its infancy would be necessary, and hence the retention throughout life of the claws and the long grasping hand.

The wing, then, of the young Hoatzin must be regarded as a unique survival of primitive times, showing that the young of the earliest birds were not only precocious, but hatched in an arboreal nursery. If this be so, it becomes highly probable that the conditions which obtain in the young Hoatzin were at one time general among birds. Certainly we have the strongest evidence in support of this view in the wings of the common fowl, the turkey, or the pheasants, for example. Although these birds are no longer hatched in trees, we find in them the same developmental stages as those met with in the Hoatzin, but with certain modifications easy to interpret.

If the wing of a chick of, say, sixteen hours old be compared with that of a young Hoatzin of the same age, it will be found that the same relative proportion between the hand and forearm exists, but that the claws are now reduced to one—that on the thumb, and this is but a mere vestige. The claw of the finger appears only during embryonic life, and is absorbed before the chick is hatched. Passing on to an examination of the developing quills with relation to the hand, we find that, as in the Hoatzin, these are at this stage restricted to the wristward region of the hand so as to leave a free finger-tip, but this and the thumb lack the cushion-like pads of the Hoatzin. Now the arrested development of these terminal quill or flight-feathers is absolutely inexplicable in a bird hatched on the ground, and only becomes intelligible when viewed in the light revealed by the Hoatzin. In other words, it can only be explained on the hypothesis that at an earlier period in the life-history of this bird, the wing was used as a climbing organ. The remoteness of this period accounts for the disappearance of the claws and the relatively shorter hand, though, as we have already remarked, this is still longer than the forearm. As in the Hoatzin, moreover, by the time that maturity is reached the relative lengths between hand and forearm have changed, the latter being longer than the former. But in one particular the wing of the young fowl differs conspicuously from that of the young Hoatzin. This is in the remarkably rapid development of the flight-feathers or quills. The growth of these in the Hoatzin is a comparatively slow process, occupying many days, but in the fowl and its allies they are beginning to unfold when the chick is but sixteen hours old, and in three days they form an efficient

organ of flight. The explanation of this accelerated development of the quills is not far to seek—it is the result of adaptation to the changed environment. The descent from the trees to the ground was a descent from comparative security from enemies into a world where enemies were numerous. Precocious flight was the method of escape adopted, though, as we shall see presently, not the only method.

But how comes it, some may ask, that the arboreal nursery was forsaken, if it afforded such security from enemies? And, further, how is it that the young of all birds hatched in trees at the present timo—save only the Hoatzin—are so singularly helpless at birth?

As touching the migration from the forest to more open ground, we may surmise that this probably took place as a result of overcrowding. The old habitat left behind, the young in response to the new environment underwent modification, now in one direction, now in another, to bring them into harmony with their particular requirements.

Among the forms known as Game-birds, and the Tinamous, the most striking of these changes is that affecting the wings, the nature of which we have just sketched in the wing of the common fowl. But we would draw special attention to one further point concerning the accelerated development of the quills. This forcing, it is instructive to note, affected *only* those quills originally concerned in the precocious flight; those at the tip of the wing, whose development was retarded so as to leave the claw free for climbing purposes, still remaining unaffected. This is as we might expect, for just as these inner quills were sufficient during the arboreal phase, they remained and still remain, equally so for all the demands of the terrestrial life.

The fact that similar traces of an arboreal life are not to be found in the precocious young of birds other than Game-birds, is a curious and extremely interesting point, and not only reveals a change in the tactics adopted for the escape of enemies, but draws attention to another and what we may regard as a second string to the bow, practised by the Game-birds themselves. It must be remembered then that these latter are reared in comparatively large families, and that they in consequence afford a conspicuous and tempting prey to prowling carnivora. Accordingly, as soon as danger is realized by the parent, the alarm is given and the young scatter in all directions. Halting at last, they then fall back upon this "second string"—protective coloration. That is to say, they have, in addition to the remarkably accelerated flight, also acquired a peculiar type of plumage which enables them to assimilate with the surrounding objects. Now it would seem that this precocious power of flight has not proved a really satisfactory method of escape, inasmuch as in fleeing from immediate danger, the young either strayed too far to render recall possible, or they fled into new danger. Consequently, the young in other groups have come to rely either on protective coloration alone, or at most *run* but a few yards and then squat down. Or, as in the case of one of the Coursers, the parents cover the young with earth. On this account, then, other groups have discarded the doubtful refuge afforded by precocious flight, and with it the evidence of these earlier arboreal habits. The young of aquatic birds obviously do not need to seek safety in flight. Concealment amid reed-beds or other vegetation affords ample protection. Among all these non-flying young we find the development of the quills has been retarded rather than accelerated, so that they appear together with the rest of the body plumage. Among the ducks, indeed, the quills do not appear till extremely late, so that the body has attained almost its full size before the wing begins to attain its adult form.

The wing of the nestling Rhea—the South American Ostrich—still retains traces of evidence of a developmental history, precisely similar to that of the forms which we have been discussing. Whether such traces will be found in the other flightless members of the Ostrich tribe, remains to be seen. In the Tinamous, the only Ostrich-like birds which have retained the power of flight, the development of the wing is precisely similar to that which obtains among the Game-birds.

This is a point of some considerable importance, since it shows that, as we have reason to believe on other grounds, the giant members of the Ostrich tribe have attained their present conspicuous bulk comparatively recently, that is to say, *since* they became flightless. That they are primitive types there can be no possibility of doubt, but, like other primitive types, their great size is the last developmental phase in their life-history, and precedes extinction. But of this more anon.

It is time that we turned to the opposite side of this picture—to the consideration of those types of nestlings which are ushered into the world blind, naked, and helpless. According to the terms of our argument, birds were originally a strictly arboreal group, and their young, like those of reptiles, were extremely active from the moment they left the shell.

Without doubt, such activity in an abnormal nursery must have been attended by considerable infant mortality through the young falling to the ground. Many, probably, would fall through weakness; the habit of dispersing themselves among the branches of the trees in which the nest was placed resulting in a loss of regular food supply, owing to the difficulty of being on the spot when the parents returned with food.

Now two courses were open whereby this infant mortality could be reduced. Either the eggs could be deposited on the ground, or the activity of the young could be curtailed. The game-birds, ducks and geese, rails, cranes and plovers, may serve for examples of those species which have descended from the trees to the ground for nesting purposes. Although, as a consequence, such young have undergone considerable changes in adaptation to their new environment, these changes are not so striking as those which have taken place among the young of the species which, retaining the ancient practice of nesting in the tree tops, have adopted the alternative of curtailing the activity of their offspring. This curtailment was accomplished by reducing the amount of food-yolk enclosed within the egg. As a consequence of this reduction the embryonic period of development has become relatively shortened, and the young in consequence emerge from the shell in the helpless condition to which we have referred already.

The number of species which have adopted this expedient outnumber those which have not, and this speaks volumes for its success. As examples we may cite the vast army of song birds, the parrots, cuckoos, birds of prey, cormorants and their allies, and the stork tribe.

Though the young of these birds are all born in an extremely helpless state, they differ, it must be noticed, in one very interesting particular—the majority, when they leave the shell, are perfectly naked, whilst others are enveloped in a coat of down, and in some the down develops soon after hatching. This variability in the matter of plumage furnishes indirect testimony in support of the theory which we set out to maintain.

The amount of food-yolk once reduced, return to the older fashion of active young became impossible; and this explains why helpless young are still born to those parents which have adopted the practice of depositing

their eggs upon the ground. It proves that the arboreal nursery was forsaken *after* the adaptation to the tree-dwelling life had taken place.

Some birds, it should be noted, like the cormorants, herons, and certain of the gull tribe, to take a few examples, build as occasion demands, either on the ground or in trees. It is probable that we should be correct in approximately estimating the relative length of time which has elapsed since this specialization by the amount of down which the young develop. Thus it is probable that the storks and birds of prey, for example, came under the influence of this liberty-curtailing factor later in time than the song-birds, or Parrots and Kingfisher for example. In the storks, and birds of prey—and herein we may for the nonce include the owls—the young are invested in a coat of woolly down immediately after birth. In the song-birds, only tufts of extremely weak down make their appearance, and these are not numerous enough to effectually cover the body. In the Kingfisher even these are wanting. By way of lending still further support to this view, we have evidence that the young of some birds are at the present day slowly undergoing this process of "hobbling"—for such it amounts to—and for reasons quite different to those which we have just been reviewing. These are the gulls and petrels. The young of the former are, as yet, only reduced to a condition of partial helplessness; those of the latter have become completely so. Both, it is to be noted, have a very thick clothing of down, and both are reared in nurseries built upon the ground, and appear to have been so reared from time immemorial. Breeding in large colonies, however, or on the ledges of precipitous cliffs, the reduction of the food-yolk and helplessness of the young are obviously advantageous, since it would be impossible for the parents to recognise their own offspring if fully active and running about among those of their neighbours. In consequence, a large number would almost certainly go unfed and soon starve, whilst great activity among the young of the cliff-breeding species would be accompanied by an enormous mortality owing to falls from the cliffs. They have in consequence been starved into sedentary habits, by cutting off the embryonic food-supply exactly as in the case of arboreal birds. The life-history of the young albatross is sufficiently remarkable to deserve special mention here. Whether on account of the nature of the food, or of a constitutional habit, is not known, but by the time it is six weeks old it has become literally a mass of fat. This condition attained it is forsaken by the parents and remains on the nest unattended for, it is said, twelve months; during which time it is nourished only by the absorption of this reserve store!

Whilst a large number of birds have adopted the expedient of curtailing the activity of the young, and thereby have increased the burden of family cares, there are a few species of Game-birds known as Megapodes, or mound-builders, which have succeeded in reducing the ties of offspring to the smallest possible limits—without descending to parasitism—by enormously increasing the size of the egg so as to include a proportionately large amount of food-material for the developing embryo. As a consequence, the whole of the normal nestling period is passed *within* the shell, and the young bird emerges fully feathered and able to fly. The parental instinct seems, in consequence of this habit, to have become well nigh extinguished, for there is no brooding of the eggs, and little or no care displayed for the chicks. The eggs are deposited either in a huge mound of decaying vegetable matter scraped together by a number of birds, or in sand warmed by hot-water springs, and here they are left to hatch. Some species, it is said, hover around in the neighbourhood of the nest and assist the young birds to escape by scratching away the earth, but in the majority of cases no such solicitude appears to be displayed.

That the Megapodes were originally hatched in trees, like the young Hoatzin, there can be no doubt; since, like the latter, the wing of the young shows a free finger-tip, and an arrested development of the outer quills, characters which, as we have already seen, are direct adaptations to the peculiar locomotion of tree-climbing nestlings. Further, we may feel sure that the increase in the amount of food-yolk did not take place until some time after the descent to the ground for nesting purposes, since the wing of the young Megapode forms an exact counterpart to that of the young fowl or turkey. Had the increase taken place earlier, the wing would have resembled that of the Hoatzin in the possession of large claws. These are now present only during embryonic life.

The increase in the food-yolk, allowing the earlier nestling stages to be passed within the egg, must be accounted for by supposing the adult Megapode to have been obliged to adopt this expedient to avoid perils attendant on normal incubation; perils which may since have passed away, leaving no record of their nature. A return to the normal method of incubation is now impossible, the instinct therefor having been replaced by that which induces the birds to bury their eggs and leave them to be hatched by heat other than that of their bodies.

This remarkable habit of burying the eggs has received a quite different explanation to that adopted here, and one which seems to be founded on a confusion of the difference between cause and effect. The great size of the egg, say the supporters of this hypothesis, takes up so much room within the body cavity that only one can ripen at a time, and consequently long intervals must elapse between the deposition of each egg. To wait till all were laid would be dangerous, and, furthermore, they could not all be covered by the sitting bird. Consequently, each is deposited as it is laid, in an incubator, and left to take its chance, just as obtains among the reptiles. They hold, in short, that the Megapodes lay their eggs in mounds because of their size; whilst the converse appears to be the case—the large egg has been produced because of the need of depositing it in some natural incubator, the parent being unable to undertake this duty.

It may seem to some that we have drifted a long way from our starting-point. A moment's reflection, however, will show that this is not really the case. We set out by showing that the vestiges of claws present in the wings of modern birds are something more than mere survivals of a reptilian phase of development. That they are indeed remnants of organs once of extreme importance; primarily during the nestling period, and, secondarily, during the moulting periods of the life-history of the earliest birds. Later, their use became restricted to the nestling period only, whilst to-day they are functional only in a single species—the Hoatzin. The degeneration of these claws followed in consequence of the introduction of changes in the nursing of the young, whereby the use of the claws was abolished, and infant mortality became at the same time reduced. Thus, then, these vestiges of once useful organs prove to be indices of the highest importance, throwing a flood of light on what would otherwise have remained an impenetrable mystery.

CYCLES OF ECLIPSES.

By A. C. D. CROMMELIN.

PART III.

THE 300^y CYCLE.—It seems to me that this is a cycle of considerable utility. It is easily remembered, being an

exact number of centuries, and it frequently repeats the track of totality with considerable accuracy. In fact we can say with confidence that whenever the sun is totally eclipsed at a considerable altitude (totality not being very brief) there will be a total eclipse 300^y later not very far away. When the sun is very low, foreshortening may shift the track considerably, as, for example, 1598 total in Scotland with low sun, 1898 total in India. But the other three eclipses on the diagram are repeated much more closely; notice in particular the resemblance of 1600 to 1900. It may be added that in 2200 this will be total in the North of England (Rev. S. J. Johnson). As other examples of the cycle, we may give 1560 (Spain), 1860 (Spain), 2160 (France). 1551 (Norway), 1851 (Norway), 2151 (England). 1415 (France), 1715 (England), 2015 (near Shetlands). 1424 (Germany), 1724 (England), 2024 (Atlantic). 1781 (N. Africa), 2081 (France), 2381 (England; this is from Rev. S. J. Johnson). 1406 (France; given above in the 521^y cycle), 1706 (Switzerland), 2006 (Egypt).

The above are all total eclipses; examples might be multiplied *ad libitum*, but the above will suffice to establish the utility of the cycle.

It may be noted that a 246 year cycle (viz., 300^y minus the triple Saros) satisfies B, C, E better than the 300^y. But it satisfies D so badly that it is not really so useful, besides being much harder to remember. Mr. Stockwell suggested the use of a 372^y cycle (that is 300^y plus four Saroses). He thus satisfies condition D, but at the cost of B, C, which it satisfies so badly that it does not need further consideration.

Note.—Mr. E. W. Maunder has drawn my attention to the fact that a 600 year period (viz., two of these periods) was known to the ancient astronomers, though there does not seem to be much evidence as to how it was discovered. Josephus ("Antiquities of the Jews," Chap. III.) says that the ancients had "a longer time of life on account of . . . . the good use they made of it in astronomical and geometrical discoveries, which would not have afforded the time of foretelling [the periods of the stars] unless they had lived 600 years; for the Great Year is completed in that interval."

The Megalosaros.—This is by far the best long eclipse period known, and bears a remarkable analogy to the Saros, as will be seen by the schedule above. It was discovered a few years ago by M. Oppert; he apparently deduced it from theoretical reasoning, not from a study of tabulated eclipses, as the Chaldæans discovered the Saros. He considers that this period was known to the ancients, which, however, seems to be very improbable on the face of it, and to require convincing evidence to establish it.

In this long period the secular acceleration of the moon, which causes her to go quicker and quicker each century, becomes an important factor. It is possible that New-

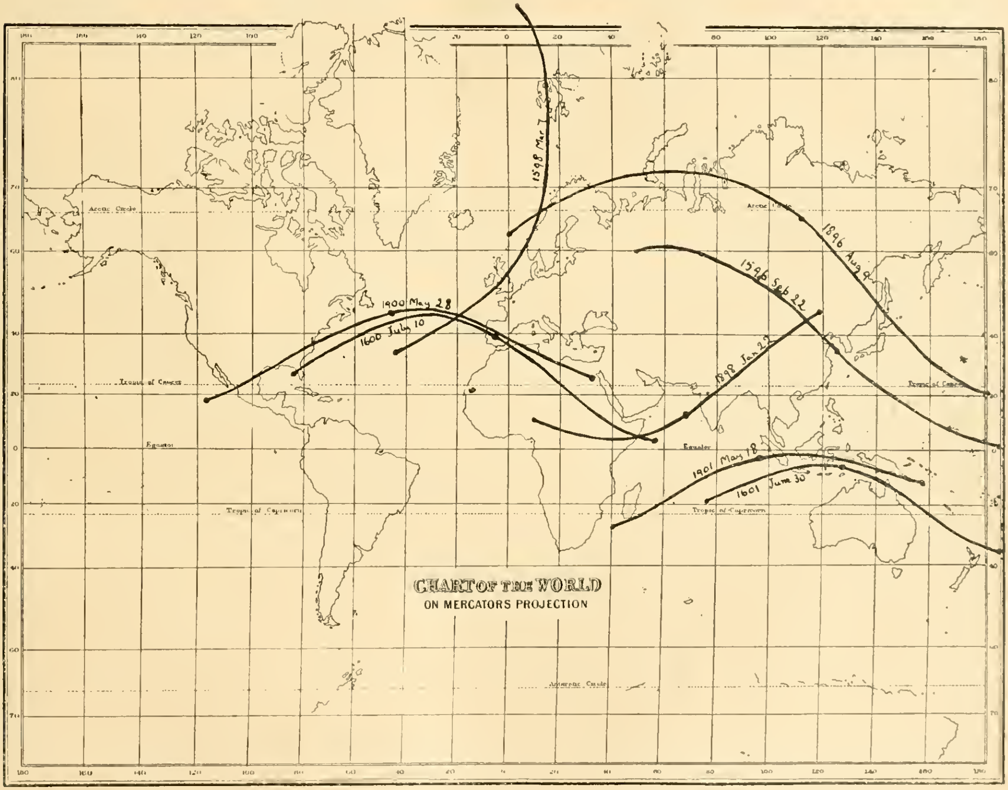


Plate III.—The 300-year Cycle. The last four Total Solar Eclipses and their counterparts three centuries earlier.

comb's value of this quantity is more accurate than Oppolzer's, and therefore that the latter's tracks for ancient eclipses are somewhat in error; however, in the case of the eclipse of Thales in the year −584, Oppolzer's track is only 7° east, 1° north of Newcomb's, so that the Canon is sufficiently accurate for the purposes of this paper.

It will be seen from the schedule that condition B was rigorously satisfied about the year 650 A.D. (*i.e.*, when this is the middle year between the two eclipses). Also condition C was rigorously satisfied about 1130 A.D., so that the cycle about that time was well-nigh perfection; it is now slightly deteriorating, though it will remain a most serviceable cycle for ages to come.

between the two eclipses. The shift in longitude is given for five different types of eclipses, viz.:—

(1) Total eclipses, long totality. Oppolzer's U'_a between ·53 and ·54.
(2) ,, ,, short ,, ,, ,, ,, ·54 ,, ·55.
(3) Annular-Total eclipses. ,, ,, ,, ·55 ,, ·56.
(4) Annular eclipses, short annularity. ,, ,, ,, ·56 ,, ·57.
(5) ,, ,, long ,, ,, ,, ,, ·57 ,, ·58.

We select the class that suits our eclipse, and can at once read off from the diagram the shift in longitude and latitude; whence we obtain the positions of the sunrise, noon, and sunset points of the track and can approximate pretty closely to the intervening positions.

As an example I take the eclipse of 2381, July 20; its predecessor occurred 576, July 11, being a descending node

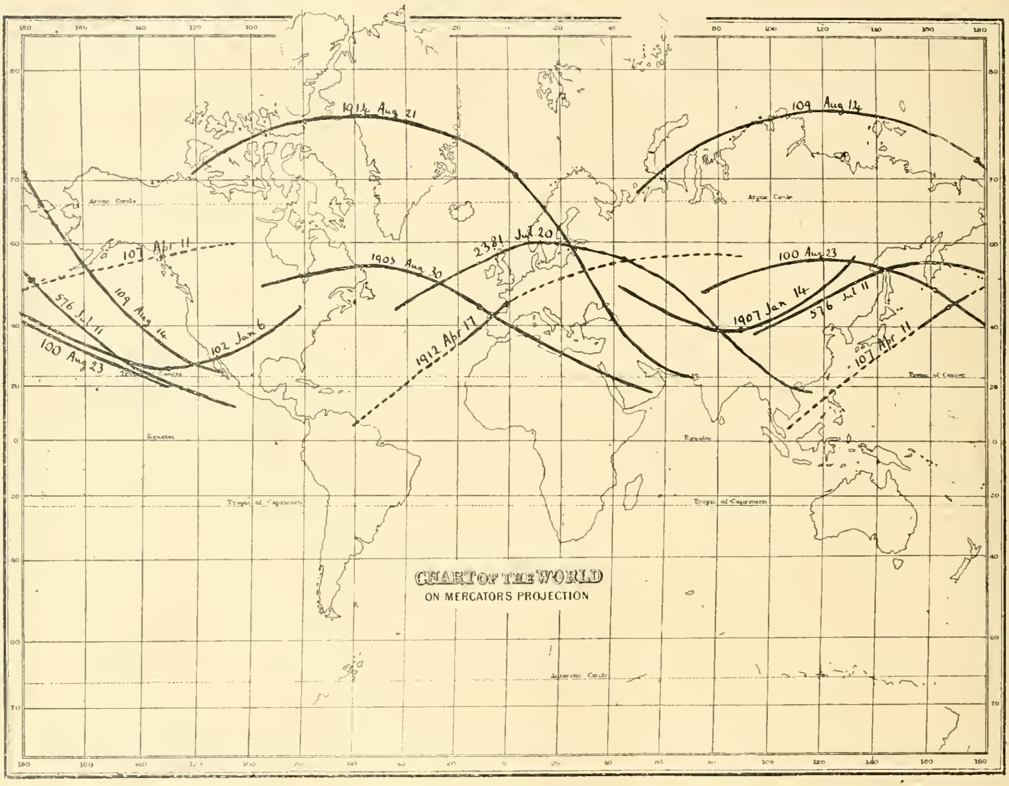


PLATE IV.—Diagram illustrating the Megalosaros. The Eclipses of 1905, 1907, 1912, 1914, 2381, are compared with their counterparts 1085 years earlier.

To obtain the westward shift of the second eclipse of a pair compared with the first, we have merely to multiply the fraction of a day in the length of the period (column 4 of the schedule) by 360°. The result comes out 139°·3 westward when 1800 is the middle year of the interval, 197°·0 westward when −700 is the middle year.

I have constructed a diagram by which the shift of the second eclipse from the first, both in longitude and latitude, may be obtained by inspection.

The year at the top of the diagram is the mean year eclipse, and belonging to the long-totality class. The mean year is 1478, and our diagram gives the westward shift as 139°, the northward shift as 5°, whence using Oppolzer's position for the earlier eclipse we obtain the following:—

	576.	2381.
Sunrise point ...	94° East, 39° North...	45° West, 44° North.
Noon ,, ...	176° West, 52° ,, ...	45° East, 57° ,,
Sunset ,, ...	106° ,, 13° ,, ...	115° ,, 18° ,,

These points have been plotted on the map. For filling

in the track I have made use of the "Nautical Almanac" for 1860, as the eclipse of July 18 in that year is the corresponding eclipse in the 521 year cycle, and has a similar track as regards latitude.

It will of course be understood that the tracks predicted by the Megalosaros do not claim perfect accuracy; there is, in fact, an uncertainty of some 25° in longitude, 6° in

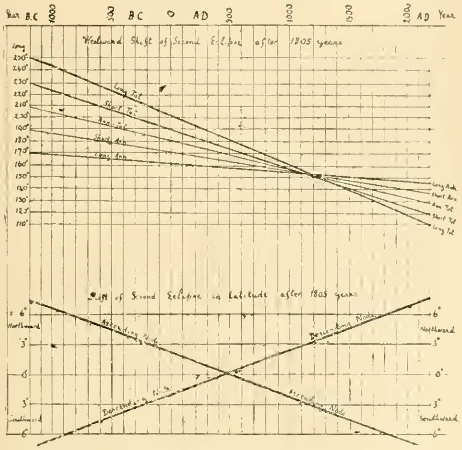


Diagram giving the Shift in Longitude and Latitude of Eclipse Tracks in the Megalosaros.

latitude. The cycle gives us, however, a close approximation with a minimum of labour, and enables us to select the eclipses that are likely to prove interesting in any given period.

Thus the eclipse of 2381 is total in central England at 10h. 12m. a.m. (Rev. S. J. Johnson, "Eclipses and Transits in Future Years"), from which it appears that the track, as predicted by the Meg., requires to be shifted westward and southward through several degrees.

It may be of interest to give an illustration of the application of the Meg. to an eclipse in the remote past, the eclipse of Ho and Hi in China. Rev. S. J. Johnson suggests, among others, 2126, October 13, as the date, and says, "on this date I find an eclipse visible in China did occur, but I have not looked into the circumstances of it." The corresponding eclipse 1 Meg. later occurred, 321, September 26. It was at the descending node, and belonged to the long-annularity class. The mean year is −1224, and from our diagram we obtain:—westward shift, 170°; southward shift, 8°.

Whence we obtain the following, using Oppolzer's position for the later eclipse:—

	−321.		−2126.
Sunrise point ...	107° West, 54° North	...	63° East, 62° North.
Noon ,, ...	36° ,, 29° ,,	...	134° ,, 37° ,,
Sunset ,, ...	20° East, 5° South	...	170° West, 3 ,,

I have not inserted these tracks on the map, which is already sufficiently crowded, but it will be seen that the track of annularity in −2126 must have passed through or near China, in accordance with Rev. S. J. Johnson's statement.

In conclusion, I would express my great indebtedness to Oppolzer's great work the "Canon of Eclipses." The amount of labour that its preparation must have involved is well-nigh incredible, and the amount of assistance that it gives in identifying ancient eclipses or studying the laws of their recurrence is immense. In fact it quite supersedes all cycles and other approximate methods for the period which it covers, and relegates their use to the extremely distant past or future.

But though the study of eclipse cycles has not now the same importance that it had to the ancient Chaldæans, it is still instructive and, I hope, not uninteresting, giving us a clearer conception of the nature of the motion of the sun and moon, and impressing us with a sense of the majestic law and order which prevail throughout the universe.

THE CHEMISTRY OF THE STARS.

V.—THE ORION STARS.

By A. Fowler, F.R.A.S.

The true character of the spectra of the Orion stars was not realised until photographic methods were introduced. Rutherfurd—one of the earliest observers of stellar spectra—was unable to see any lines whatsoever, and this also has been the experience of many subsequent observers, even in some cases where large instruments have been employed. Nevertheless, Secchi, in 1863, published a drawing of the spectrum of Rigel showing no less than ten dark lines, among which the C and F lines of hydrogen were conspicuous. In most of the Orion stars, however, the lines are so difficult of observation that even so experienced an observer as Vogel described them in 1874 as "spectra in which the metallic lines are few in number, and very faint or entirely imperceptible, and in which the hydrogen lines are lacking." Later observers, including Prof. Campbell, have been able to identify the D_3 line of helium as well as some of the lines of hydrogen, but the fact remains that it is to photography that we owe practically all our knowledge of this interesting and important group of stars.

The photographic delineation of the spectra was for a time far ahead of their interpretation. Up to 1895, the lines of hydrogen, two lines of calcium, and a solitary line of magnesium (λ 4481) were the only ones recognised as having anything in common with terrestrial chemistry. One important relation, however, had been arrived at, namely, that some of the lines were identical with lines associated with D_3 in the spectrum of the solar chromosphere, and therefore presumably originated in the then hypothetical gas, helium. Suspicion was converted into certainty on the discovery of terrestrial helium by Sir William Ramsay in 1895. It was then shown by Prof. Vogel, Sir Norman Lockyer, and others, that most of the stronger Orion lines, always excepting those of hydrogen, corresponded in every particular with the lines of the newly-discovered gas, and thus received a completely satisfactory chemical explanation. The lines of helium are, in fact, the most characteristic feature of the Orion stars.

The mystery still surrounding other important lines was shortly afterwards dissipated by Sir Norman Lockyer's identification of some of them with lines of silicium and carbon, and by Dr. McClean's remarkable discovery that several lines were due to oxygen. Not less unexpected was the subsequent discovery that nitrogen was responsible for some of the remaining lines. The lines not yet accounted for are mostly feeble, and their eventual identification with lines of terrestrial substances may be reasonably expected.

The Orion stars, however, are not by any means all of the same pattern. Some of the lines are of different intensities in different stars, and lines found in one may even be absent from another. Signs are not wanting that these differences are due to the different stages which the

stars have reached in an evolutionary process, and there is abundant evidence to show that the nearest relations of the Orion stars are stars of the first type. Including such stars as γ Argus, which show bright as well as dark lines in their spectra, Lockyer classifies the Orion stars in eight groups, and suggests their arrangement in the following evolutionary order:—

Argonian (γ Argus).
Alnitamian (ϵ Orionis).

Crucian (α Crucis).	Achernian (α Eridani).
Taurian (ζ Tauri).	Algolian (β Persei).
Rigelian (β Orionis).	Markabian (α Pegasi).

On the left are the stars believed to be of increasing temperature, following α Cygni in the evolutionary scheme, and on the left those of decreasing temperature, which are immediately succeeded by stars of the Sirian group. The maximum of stellar temperature is considered to be represented by the two groups which head the list.

It is not necessary here to describe in detail the differences between the several groups. Suffice it to say that in passing from the Rigelian to the Alnitamian group there is a general diminution in the strength of the enhanced metallic lines, accompanied by an increase in the intensities of the lines of helium, while in passing from the Alnitamian to the Markabian group there is a similar change in the inverse order. Stars on the down grade are distinguished from those of similar temperature which are becoming hotter by the greater intensity of the lines of hydrogen, and the lower intensities of the additional lines as a whole.

The Alnitamian group is especially distinguished by the presence of a series of lines of hydrogen first discovered in ζ Puppis by Prof. Pickering, the wave-lengths of which bear a simple numerical relationship to the series of lines of that gas with which we are familiar in the Sirian stars and in the spectra obtained from Geissler tubes. This new series has not yet been experimentally reproduced, but the similarity with other spectra which form "series" justifies the belief that it is produced by hydrogen in a particular but, at present, unknown state; Miss Clerke distinguishes this form of the gas from the ordinary form by the appropriate title "cosmic hydrogen," while Sir Norman Lockyer calls it "proto-hydrogen." Another important line at λ 4687, as Rydberg has shown, is in all probability a line of the "principal" series of hydrogen (the others forming the two "subordinate" series), and the only one which comes within our present range of stellar observation. As in the case of the Pickering series, all efforts to reproduce this line in the laboratory have so far been fruitless, owing probably to lack of means to raise the gas to a sufficiently high temperature.

The Crucian variety of the Orion stars is by far the most numerous, at least among the brighter stars which have been investigated in sufficient detail for their proper classification. Among the best examples in the northern hemisphere are γ Orionis and η Ursæ Majoris, and in the southern heavens α and β Crucis. The spectrum of the latter, in which the lines of oxygen are developed to an exceptional degree, is reproduced in Fig. 10 from a photograph which we owe to the kindness of Dr. McClean. (The longitudinal streaks are due to irregularities in the driving clock, the photograph having been taken with a prismatic camera.)

The wave-lengths of the lines marked in the photograph are as follow:—

Wave-length.	Origin.	Wave-length.	Origin.
3819·7	He	4190·0	O
3835·5	H (H_η)	4254·1	O
3889·15	H (H_ζ)	4267·5	C
3926·7	He	4317·1	O
3933·8	Ca	4325·9	O
3964·9	He	4340·7	H (H_γ)
3970·2	H (H_ϵ)	4388·1	He
3995·2	N	4471·6	He
4009·4	He	4481·3	Mg
4026·3	He	4552·8 }	
4070·1 }		4568·0 }	Si
4072·4 }	O	4575·3 }	
4076·3 }		4649·2	O
4101·8	H (H_δ)	4713·3	He
4121·0	He	4861·5	H (H_β)
4143·9	He		

From the detailed tables of stellar lines which have been published by Sir Norman Lockyer, we gather that the chemical elements hitherto identified in four typical stars of the Orion class are as follow:—

β Orionis.	ζ Tauri.	γ Orionis.	ϵ Orionis.
Calcium	Aluminium?	Calcium	Calcium
Carbon	Calcium	Carbon	Carbon
Chromium	Carbon	Helium	Helium
Helium	Chromium	Hydrogen	Hydrogen
Hydrogen	Helium	Iron?	Magnesium
Iron	Hydrogen	Magnesium	Nitrogen
Magnesium	Iron	Nitrogen	Oxygen
Nickel	Magnesium	Oxygen	Silicium
Nitrogen	Manganese?	Silicium	
Oxygen	Nickel	Titanium?	
Silicium	Nitrogen		
Titanium	Oxygen		
	Silicium		
	Titanium		
	Vanadium?		

The paucity of substances actually represented by spectrum lines in these stars is not necessarily at variance with the view that all stars are fundamentally of the same composition. We know from laboratory experience that the elements contained in a mixture are not always equally effective in making their presence known in the spectrum. Again, it is usually only the reversing layer that gives any intelligible information as to the composition of a star, and it may be that many substances fail to show themselves in the absorption spectrum just as the D_3 line of helium writes no record in the dark line spectrum of the sun. Or, as Sir Norman Lockyer supposes from the stellar evidence, metallic substances such as iron, submitted to the transcendental temperatures of the hottest stars, may be dissociated into hydrogen and helium. In one or all of these ways the absence of legible indications of so many

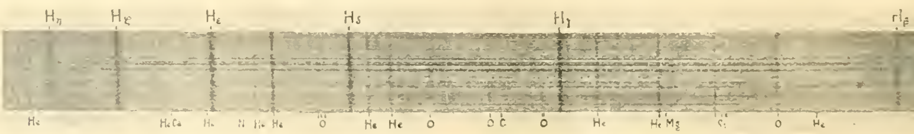


FIG. 10.—The Spectrum of β Crucis, showing the origins of some of the principal lines.

NORTH.

EAST.

WEST.

SOUTH.

PHOTOGRAPH OF THE SUN IN "K-LIGHT," SHOWING CALCIUM CLOUDS.

Taken with the Rumford Spectroheliograph, attached to the great 40-inch Refractor of the Yerkes Observatory, by Prof. GEORGE E. HALE and Mr. FERDINAND ELLERMAN, 1903, April 27, 10h. 52m., Central Standard Time.

substances from the Orion stars may possibly be accounted for.

The argument for the identity of composition with other groups of stars is based on the continuity of the spectral phenomena. Just as in passing from stars of the second to stars of the first type the ordinary metallic lines give way to the enhanced lines, so in proceeding onwards to the Orion stars these lines are themselves displaced by lines chiefly due to gases. The changes are never abrupt, and it is this unbroken sequence which leads to the belief that the different types of stellar spectra indicate different stages in the evolution of similar masses of matter.

The names of some of the brighter Orion stars, with the groups to which they belong in Lockyer's classification, are given in the following table :—

Rigelian.	Taurian.	Crucian.	Alnitamian.	Achernian.	Algolian.	Markabian.
β Orionis	λ Tauri	γ Pegasi	δ Orionis	ζ Cassiopeiæ	β Persei	α Andromedæ
β Tauri	ζ Tauri	ζ Persei	ϕ^1 "	α Eridani	δ "	α Doradus
67 Ophiuchi	o^2 Canis Majoris	ε Persei	λ "	ε Cassiopeiæ	Pleiades*	β Canis Minoris
	η Canis Majoris	γ Orionis	ι "	κ Draconis	α Columbæ	γ Ursæ Majoris
		β Canis Majoris	ε	ζ Coronæ	α Leonis	α Canum Venaticorum
		α Crucis	σ "	ζ Draconis	β Libræ	α Draconis
		α Muscæ	"	η Lyræ	θ Aquilæ	α Coronæ
		β Crucis	κ "	α Gruis	α Delphini	γ Lyræ
		α Virginis		β Piscium	ζ Pegasi	δ Cygni
		η Ursæ Majoris				α Pegasi
		β Centauri				
		β Scorpii				
		ζ Ophiuchi				
		α Pavonis				
		β Cephei			* Principal Stars.	

It will be observed that the Orion stars are by no means restricted to the constellation of Orion, except in the case of the Alnitamian group, the brightest members of which are the three stars forming the belt of Orion. The name Alnitam (often erroneously spelt Alnilam) in fact means "a belt of spheres or pearls."*

A study of the distribution of these stars on the celestial sphere, and of their proper motions, has proved most instructive. It is found that the great majority of them lie near the plane of the Milky Way, and their vast distances are indicated by the almost invariably small proper motions, so that the two results together seem to suggest that the Orion stars form a ring of almost inconceivable magnitude.

* Lockyer, *Roy. Soc. Proc.*, vol. 65, p. 187.

THE SUN AS PHOTOGRAPHED ON THE K-LINE.

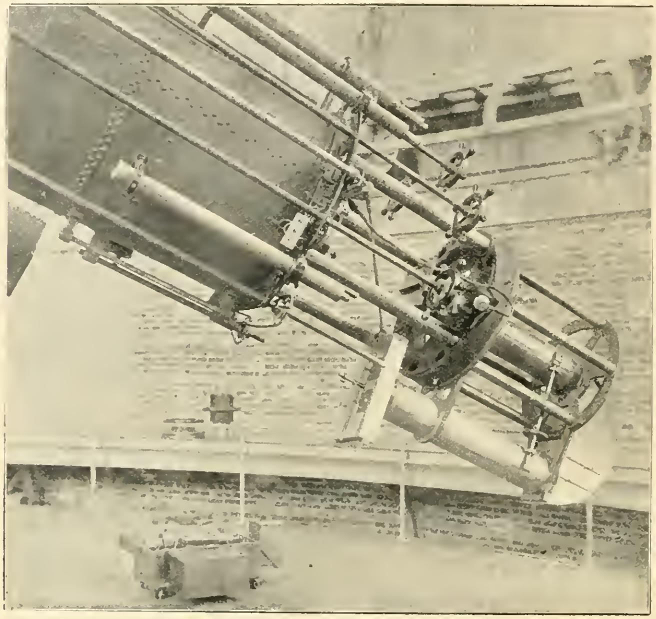
In Knowledge for January, 1894, Prof. G. E. Hale published two photographs of the sun, which he had taken in monochromatic light by means of the spectroheliograph, using for this purpose the K-line of calcium. We are now able to place before the readers of Knowledge, again by the kindness of Prof. Hale, a recent photograph of the sun in K-light, which, by its great beauty and sharpness of detail, affords an index of the progress which has been made in perfecting the instrument, and the method of work.

The Rumford spectroheliograph, with which the photograph was taken, is attached to the great 40-inch refractor of the Yerkes Observatory. As the focal length of that telescope is 64 feet, the image of the sun in the principal focus is slightly over 7 inches in diameter. The objectives (portrait lenses) of the collimator and camera of the spectroheliograph are each $6\frac{1}{4}$ inches in aperture, with focal lengths of about 33 inches. After passing through the collimator lens the light falls upon a plane mirror, from which it is reflected to a train of two 60° prisms, set at minimum deviation for the K-line. A second slit is placed close to the focus of the camera lens, and in the case of the photograph in question, was set at the centre of the K-line. The great 40-inch telescope is made to move slowly in declination by means of a slow-motion electric motor, and the sun's image consequently moves at a uniform rate across the first slit. The photographic plate is at the same time driven at the same rate across the second slit by means of a shaft led down the tube of the telescope from the motor. In the accompanying photograph a double Hooke's joint is shown connecting this shaft with the end of the screw which drives the plate, but this has now been replaced by a belt connecting grooved pulleys on the ends of the shaft and the screw respectively. The two slits are each 8 inches in length, and are given the proper curvature necessary to eliminate distortion of the solar image. But the aperture of the spectroheliograph is not quite sufficient for a 7-inch image of the sun, and this occasions much loss of light at both ends of the long slit, and is the cause of the falling off in brightness at the two opposite limbs of the sun, which will be noticed in the plate.

A comparison of the photograph on the plate with an ordinary photograph of the sun, taken on the same day with the Thompson photoheliograph of the Royal Observatory, Greenwich, shows three very striking differences between them. The "mottling" on the K-line photograph is far more pronounced, and its reticulations display a more open mesh than the "white-light" photograph taken at Greenwich. Next, the bright calcium clouds, of which five principal groups are seen in the plate, though they correspond in position to the groups of faculæ shown on the Greenwich photograph, and even to a very considerable extent in form, are more extensive and, especially near the centre of the sun, far more distinct. Prof. Hale proposes, for the sake of clearness, to give these calcium clouds a specific name, and suggests the name "Flocculi" for them. Thirdly, the dark spots cover a much greater area on the Greenwich photograph than on that taken by the Yerkes spectroheliograph. This is due to the way in which these bright calcium Flocculi extend themselves above the spots, concealing the greater part of each group. The three principal spot-groups are the same as those shown in the plate of the June number of Knowledge, which is a reproduction of a photograph taken three days later than the present one. The great calcium cloud halfway between the sun's centre and the north limb, in the present plate, corresponds to the spot-

group G, shown on p. 131, and it will be seen at once that the smaller preceding spots of the group are entirely hidden by the ramifications of the Flocculi.

Prof. Hale, in a communication describing his instrument and its work, writes:—"By setting the second slit on various parts of the K-band, it is possible to photograph sections of the calcium flocculi at different elevations above the photosphere. This is due to the fact that the width of the K-band is determined by the density of the vapour; hence, if the slit is set near the outer edge of the broad band, it can receive light only from the calcium vapour, which is dense enough to produce a band of this width. When the slit is set near the centre of the band it receives light from all the vapour lying below the corresponding level. But as the vapour expands as it rises, a given photograph always shows the structure corresponding to the lowest density (highest level) of the calcium vapour competent to produce a line of the necessary width. I shall publish very soon a series of photographs showing how spots are successively covered by overhanging calcium clouds in photographs taken at different levels.



The Rumford Spectroheliograph of the Yerkes Observatory.

"If sufficiently high dispersion is used, photographs can be taken with any of the dark lines of the solar spectrum. For example, I have succeeded in obtaining hydrogen and iron pictures by using a grating in place of the plane mirror in the optical train of the spectroheliograph. The grating gives a spectrum which is afterwards further dispersed by the two prisms. The prisms also serve to reduce greatly the diffuse light from the grating by spreading it out into a spectrum. Photographs taken with the hydrogen lines give *dark* structures scattered all over the sun. In many cases, especially away from sunspots and other disturbed regions, these *dark* hydrogen regions correspond closely in form with the calcium flocculi. But in the neighbourhood of sunspots there are frequently very marked differences of an interesting kind. In much disturbed regions *bright* hydrogen structures are occasionally shown. These usually correspond with very bright calcium flocculi shown in high level pictures, but it is a significant fact that no evidence of such increased brightness is noticeable in the low level calcium pictures taken at the same time. Through a comparison with the hydrogen photographs we have found that *dark* calcium flocculi are occasionally present. I shall give a brief preliminary discussion of these results in a paper which I hope to publish very soon.

"It seems to me desirable to point out that the calcium flocculi are not prominences, but are comparatively low level phenomena in the chromosphere. In the case of eruptions, very brilliant prominences are of course sometimes shown projected against the disk, but these differ decidedly from the flocculi ordinarily photographed. I am not yet in a position to state to what level the *dark* hydrogen clouds correspond. It is also important to remark that attempts to photograph the sun's disk through the dark lines will give very misleading results if low dispersion is employed. It is absolutely necessary that the dispersion be so great as to produce dark lines which are distinctly wider than the second slit of the spectroheliograph. Otherwise only the ordinary faculæ, which produce increased brightness of the continuous spectrum, will be shown on the plate."

Letters.

[The Editors do not hold themselves responsible for the opinions or statements of correspondents.]

BORRELLY'S COMET, 1903.

TO THE EDITORS OF KNOWLEDGE.

Sirs,—The accompanying photographs were taken with a reflector of $6\frac{1}{2}$ inches aperture and 28 inches focus, fixed on to an $8\frac{1}{2}$ inch equatorial reflector.

The nucleus of the comet was kept as nearly central as possible in the corner of a thick cross-wire micrometer eyepiece, by setting the clock to drive at the rate of the comet's motion in R.A., the declination being regulated by hand.

Cadett's Lightning Plates were used, with dilute Rodinal and prolonged development, according to the method described by Mr. Ritchey at a recent R.A.S. meeting.

No. 1, taken on 22nd July, at 10h. 58m. to 11h. 30m., G.M.T.; No. 2, taken on 26th July, at 10h. 30m. to 11h. 0m., G.M.T.

A considerable change is shown during this interval of nearly four days in the structure of the tail, and it is also

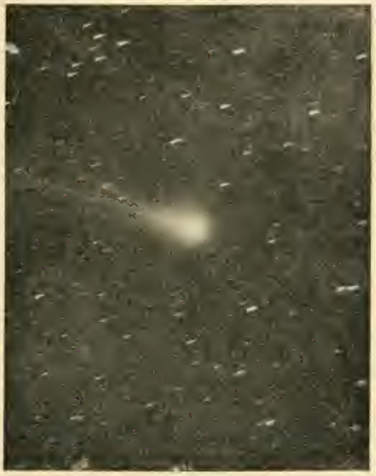
to be remarked that the well-defined fan-like rays, so well seen in No. 1 photograph, could not be perceived visually with anything like so great distinctness in the larger reflector.

The scale of the photographs taken on plates $2\frac{1}{2}$ by 2 is 0·49 inch = 1°.

R. C. JOHNSON.

SOUTH.

EAST.



WEST.

NORTH.

No. 1.—Borrelly's Comet, 1903, July 22d., 10h. 58m.—11h. 30m.

SOUTH.

EAST.

WEST.

NORTH.

No. 2. Borrelly's Comet, 1903, July 26d., 10h. 30m.—11h. 0m.

CURIOUS SUNSET PHENOMENON.

TO THE EDITORS OF KNOWLEDGE.

SIRS,—The phenomenon described by Lieut. Field, R.A., is very familiar to me. Although I have not been in India I have frequently seen it in South Africa. It requires a bright sun and a thinly-dispersed cirrus cloud in the spots where the patches appear; I believe about 22° either to right or left of the sun. I often used to watch the phenomenon when in Natal, and it could often be seen on either side of the sun.

Looking over my note books I find I recorded the same thing as seen at Gibraltar on 30th May, 1893—"a pretty coloured image of the sun to the left of that luminary."

In Ireland, January 29th, 1890, I recorded portions of a solar halo visible. To the right of the sun there was a brilliant white patch of light, shaded off with prismatic colours. There was another patch, but not quite so intense, on the left of the sun. They evidently formed parts of a circle, of which the sun was the centre, for later on, at about 10 a.m., I could trace the halo above the sun joining the coloured parts, although it (the circle) was white. The patches continued bright for about a quarter of an hour. This, it must be noted, was in the *morning*.

Lastly, I note that on April 29th, 1902, while crossing from Penzance to the Scilly Isles, I saw at about 6 p.m., a rather faint-coloured patch of light 22° (or so) to right of sun. There was a tendency to lengthen, vertically, as if part of a halo. Part nearest sun red, rest white. Sky to left of sun clear blue; but suddenly a scrap of "mare's-tail" cloud (drifting along) showed the most brilliant prismatic colouring, principally red, but also partly pure white. A very pretty sight.

It is obviously a phenomenon analagous to the rainbow, but instead of a reflection followed by refraction, I presume it is a case of refraction and dispersion only. What is the nature of the particles of watery vapour favourable to the production of these coloured patches, that is, whether in form of water, ice, or otherwise, I am not physicist enough to say, but from my experience I am certain that a thin stratum of cirrus cloud is necessary to produce them. They are commoner than supposed, and faint traces of them can often be observed by a lover of the sky who keeps his eyes open.

Salisbury. E. E. MARKWICK, Col.

METHOD OF ASCERTAINING MOON'S AGE.

TO THE EDITORS OF KNOWLEDGE.

SIRS,—Mr. Crommelin in his interesting paper on Cycles of Eclipses tells us the Saros may be used to give the rough position of the moon and age on dates for which an almanack is not available. If only the age is required there is a simpler way, which requires no almanack at all. Mr. Crommelin is certainly acquainted with it although he has not mentioned it. I am not aware where I got it from, but I continually use it mentally when I come across references to moonlight phenomena, and often find errors. It is to divide the year by 19, take the remainder, multiply by 11 and divide by 30. Take the remainder again, add the day of the month, and one for every month in the year after March, the result is approximately the age of the moon. Thus, to take Mr. Crommelin's two dates, what was age of moon March 8th, 1899, and what was age January 12th, 1809? Then $\frac{1899}{19} = 99$, and remainder 18. $\frac{18 \times 11}{30} = 6$, and remainder 18. Add this to March 8th, and we get age of moon, 26 days. In the second case, $\frac{1809}{19} = 95$, and remainder 4. $\frac{4 \times 11}{30} = 1$, and remainder 14. Add this to January 12th, and we again get age of moon, 26 days.

Just as an instance later in the year. What was age

November 26th, 1898? $\frac{1898}{19} = 99$, and remainder 17. $\frac{17 \times 11}{30} = 6$, and remainder 7. Adding 26, and 8, as November is 8th month from March, we have 41, which, less 29, is 12 days old.

While not absolutely accurate, this is near enough for many purposes.

EDWIN HOLMES.

Notes.

BOTANICAL.—*Archæologia*, Vol. LVIII., contains a report by Mr. Clement Reid on the material collected during 1902 by Mr. A. H. Lyell from the rubbish pits and old wells of Roman Silchester. This material furnished numerous seeds and other parts of plants of which twenty-four species have been determined, all being additions to the already known flora of the town as it existed in Roman times. With one exception all the plants enumerated are common wild species in this country at the present day, and many are very familiar weeds, such as *Ranunculus acris, Galium Aparine, Centaurea nigra* and *Taraxacum officinale*. The one exception is *Buxus sempervirens*, the Box, represented by clippings associated with various weeds and the common Elder. It is not possible to say with certainty whether the tree was indigenous or only cultivated at Silchester, but Mr. Reid thinks from the association of the clippings that they probably belonged to withered garlands made from wild trees, and were not garden refuse. This evidence is especially interesting in view of the fact that there has been some controversy as to whether the Box is really a native of this country or not. In his *Handbook of the British Flora* Mr. Bentham says that the Box is "found in Britain only in some localities in southern England, and even there it is doubted whether it may not have been introduced, as it has long been much planted in shrubberies." Mr. H. C. Watson ignores it altogether in his *Topographical Botany*, while in his *Cybele* he calls it a denizen. Mr. Reid's reference to the Box recalls to notice three important communications published in the *Journal of Botany* for 1901. The first of these, by Mr. G. Murray, deals chiefly with the trees growing on Box Hill in Surrey, and the second by Mr. C. Bucknall, with those in Gloucestershire. The evidence submitted by these writers leaves scarcely any doubt that the Box is truly indigenous at the former place, and also at Boxwell, near Alderley, in Gloucestershire.—S. A. S.

ENTOMOLOGICAL.—All students of the Lepidoptera in general, and the Hawk-moths in particular, owe a debt of gratitude to the Hon. Walter Rothschild and Dr. Karl Jordan for their monumental "Revision of the Lepidopterous Family Sphingidæ," which has lately been issued from Tring (*Novitates Zoologicæ*, Vol. IX., Supplement, 1903). Every species of this important family is carefully described, and the monograph marks a great advance in the study of Moths on account of the attention paid to structural details. Classification is no longer made to depend chiefly on the shape and pattern, or even the neuration of the wings. The form of the palpi, the armature of the legs and feet, and the claspers of the male insects, are all accorded their value in the systematic arrangement, while innumerable anatomical features are figured for the first time.

The current volume of the *Transactions of the Entomological Society* (1903, pp. 39—52, pls. 2, 3) contains an interesting account by Mr. L. R. Crawshay of the life-history of the beetle *Drilus flavescens* as observed in Sussex during the last three years. The larvæ have the curious habit of preying upon various small snails. A larva captures a snail and pushes it to some convenient, hidden spot; then it creeps within the shell and slowly devours the mollusc. If the snail, when the shell is seized by the beetle-larva, comes out and tries to escape or to drive the assailant away, the latter attacks it fiercely with its mandibles. Larval life may last for two or three years, and the insect passes the winter in a passive and somewhat pupa-like condition.—G. H. C.

ZOOLOGICAL.—To the August issue of the *Proceedings* of the Zoological Society Mr. Lydekker contributes an article on the nature of the callosities (the mallenders and sallenders of the old veterinary books) on the limbs of the horse family. The view that these represent vestigial foot-pads is disputed on palæontological grounds, and it is suggested that they may be remnants of decadent glands. The fact that modern horses have lost the facial glands of their extinct ancestors may, it is urged, lend some support to the latter opinion.

The description in the same journal by Mr. de Winton of a new species of pigmy antelope (*Neotragus batesi*) from the Cameroons is a matter of considerable interest, that genus (in its modern restricted sense) having hitherto been represented only by the royal antelope (*N. pygmæus*) of Liberia.

In the *Journal* of the Bombay Natural History Society for July, Mr. H. Ferguson describes two cetaceans captured on the Madras coast at Trivandrum. One of these is identified by Mr. Lydekker with *Pseudorca crassidens* (first known by a sub-fossil skeleton from the Lincolnshire fens), while the second is regarded as representing a new species of bottle-nosed dolphin, under the name of *Tursiops fergusoni*.

One object of the light-coloured area on the hind-quarters of so many ruminants, as well as quaggas and wild asses, is explained by Mr. R. I. Pocock in a recent issue of *Nature*. It has been shown by an American artist, Mr. Thayer, that the light under-parts of many ungulates which live habitually in the open in strong sunlight are for the purpose of counteracting the effects of the dark shade cast by the body, and thus rendering the animals inconspicuous. It has now been demonstrated that when an animal, with a light area on the buttocks, like the true quagga and the kiang, or Tibetan wild ass, is lying down, these light parts come into line with the white of the belly, and thus accentuate the inconspicuousness. Mr. Pocock has further shown that the reason why the true quagga and Burchell's bonte-quagga have departed from the fully-striped black and white coloration of Grant's bonte-quagga of the north-east of Africa by the development of white under-parts, buttocks and legs, the toning-down of the black stripes to brown, and the intercalation of pale "shadow-stripes," is for the purpose of rendering the animals inconspicuous in the sun-lit open veldt and karru; Grant's bonte-quagga and the other fully-striped asses, as well as the true zebra and Grévy's zebra, inhabiting more broken or bush-clad country.

According to Mr. O. Thomas (*Annals of Natural History* for August) quite a number of small spotted South American cats allied to the tiger-cat may be recognised. It is stated, however, that individuals of the same species display an extraordinary amount of variation, both as regards colour, and the form and size of the skull, so that the study of the group is beset with unusual difficulties.

According to the latest report of the commission sent to investigate the nature and cause of the "sleeping-sickness" in Uganda, there is good reason to suppose that

a species of tsetse-fly is a carrier of the disease. Parasites of the genus *Trypanosoma*—the active cause of nagana, or tsetse disease—have been found in abundance, first in the cerebro-spinal fluid, and then in the blood of victims of the sleeping sickness. As it was obvious that the parasites could not be conveyed from man to man, an insect carrier was assumed, and suspicion fell on the tsetse. Subsequently tsetse were discovered in abundance in Uganda, although previously not supposed to exist there. As the sleeping sickness is likewise new to the country, the suspicion arises that tsetse may have been introduced through the Congo and Aruwimi route from the west coast, where sleeping sickness has long been endemic.

Conducted by Harry F. Witherby, f.z.s., m.b.o.u.

Vitality in Incubated Eggs.—The disastrous weather this summer has conclusively shown the astounding vitality of eggs when much incubated, *i.e.*, eggs within a day or two of hatching but not chipped. I suppose June 19th is *the* great Partridge hatching day, and that date appeared this year to have been the climax of bad weather. So bad was it that hundreds, nay, probably thousands of Partridges, were fairly driven off their nests, though, sad to relate, a few extra devoted mothers remained at the nest and died. A great many of these deserted eggs were gathered and placed under hens, and, I believe, did badly; but very many keepers left them alone, and wisely, for the weather improved, and I know of many cases where the birds returned to their nests and successfully hatched off. One particular nest on this estate was deserted on the morning of June 19th. It was carefully watched, and the eleven eggs *were stone cold for 48 hours.* Then the bird returned, and on the 25th hatched off nine eggs.—Jos. F. Green, Taverham Hall, Norwich, 14th September, 1903.

Bird Migration.—Mr. W. Eagle Clarke, so well-known for his valuable work in connection with the study of the migrations of birds, intends this autumn to spend a considerable time on the Kentish Knock Lightship. This lightship is stationed some twenty-one miles off the mouth of the Thames, and Mr. Clarke hopes to make observations there on the east to west autumnal movements of birds across the southern part of the North Sea. It is much to be hoped that Mr. Clarke's plucky venture will meet with great success, and that his zeal and perseverance will be rewarded by opportunities of making valuable observations.

Green Sandpiper in Co. Mayo, Ireland (Irish Naturalist, September, 1903, p. 248).—Mr. Godfrey Knox records that he shot a Green Sandpiper on the Yellow River, Foxford, Co. Mayo, on June 30th last. The Green Sandpiper is a rare autumn and winter visitor to Ireland, and has not previously been recorded as occurring there in summer.

British Grey Goose (Zoologist, July, 1903, pp. 268-273).—Mr. H. W. Robinson here expresses his opinion that there is but one species each of the Pink-footed, Bean, and White-fronted Geese. He thinks "that the variations in plumage are merely due to age, and perhaps sex may also have something to do with it, although I rather doubt this latter statement." In the *Zoologist* for August (p. 315) Mr. J. A. Harvie-Brown confirms Mr. Robinson's conclusions.

On the Identification of some of the Birds mentioned by Aristotle. By T. E. Lones, m.a., ll.d., b.sc. (*Zoologist,* July, 1903, pp. 241-253.)—In this article the author discusses and gives his conclusions as to the identification of various birds mentioned by Aristotle, the identification of which has caused much controversy. Mr. Lones remarks that the genera and species of about ninety of Aristotle's birds are fairly well known, and of the remainder—about eighty in number—the genera only of about forty have been determined with more or less success.

All contributions to the column, either in the way of notes or photographs, should be forwarded to Harry F. Witherby, *at the Office of* Knowledge, 326, *High Holborn, London.*

Notices of Books.

"Theory of Observations." By T. N. Thiele, Director of the Copenhagen Observatory. (London: Charles & Edwin Layton. 1903.)—Every applied science, which is well developed, may be divided into two parts, a theoretical (speculative or mathematical) part and an empirical or observational one. Both are absolutely necessary, and the growth of a science depends very much on their influencing one another and advancing simultaneously. No lasting divergence or subordination of one to the other can be allowed. The theoretical side deals with accurate determinations and develops the form, connections and consequences of the hypotheses. These hypotheses must be changed as soon as they are seen to be at variance with observations. The empirical side of the science procures and arranges the observations, compares them with the theoretical propositions, and is entitled by means of them to reject, if necessary, the hypotheses of the theory. But it is in itself grounded on hypotheses. The form of the observations, and the choice of the circumstances that are considered essential, must be guided by theory. The present work deals with the empirical side and investigates, not observations themselves, nor the way in which they should be made, but the common rules according to which they are submitted to computation. But the first chapter on the "Law of Causality" will well repay study by those who deal chiefly with the theoretical side. In it there is especially matter for thought for the ultra-speculative, for the metaphysicians who attempt to reason back to origins and out to limits. Such attempts are simply blocked by such a statement as the following:—"In order that an observation may be free from every other assumption or hypothesis than the Law of Causality, it must include a perfect description of all the circumstances in the world, at least at the instant preceding that at which the phenomenon is observed." Nor can the assertion that "The Law of Causality cannot be proved, but must be believed, in the same way as we believe the fundamental assumptions of religion, with which it is closely and intimately associated," be exactly palatable to those—and there are many such pseudo-scientists—who make it their boast that they cannot accept as true any proposition which is not demonstrated or demonstrable to the intellect.

"Design of Dynamos." By S. P. Thompson. (Spon.) Price 12s. net.—This excellent work, on the design of continuous current generators, is well worthy of a place beside the other well-known works of the same author on the electrical engineer's bookshelf. The work is one which may be regarded as supplementary to the author's treatise on "Dynamo-electric Machinery," in fact it bears every appearance of an extension of this work, and we shall be surprised if it is not shortly to be found incorporated in a new edition of the latter. In his opening chapter, on "Dynamo Design as an Art," the author very properly points out, in the very first sentences, that dynamo design, while depending upon certain fundamental scientific principles which can be definitely laid down and taught with precision, is essentially an art, and as such only to be acquired by the aid of practice and experience. Professor Thompson expounds these scientific principles in his usual lucid style, and in addition he gives the dynamo designer the principal data which he will require, and a very good outline of the general rules which have been gradually evolved from the accumulated experience of many successful designers of these machines. After this most necessary preliminary note of warning to the reader, the author proceeds to the consideration of magnetic data and calculations, and gives various useful tables, referring in some cases to specific types, for the description of which reference must be made to his work on dynamo electric machinery. We think that the author might with advantage

omit altogether the question of calculating air-gap areas, as for practical purposes it is quite sufficient to ascertain the average magnetic density over the pole-faces, and this quantity is far more easily determined. The next chapter, on "copper calculations," as well as the following one on "insulating materials," is extremely good, and both chapters contain valuable data. We may note that on page 53 the sign of equality is omitted before the M in the first formula, which makes it unintelligible. This opportunity may be taken of pointing out how very few inaccuracies are to be found in the volume, especially considering that it is a first edition. Chapter V. deals at considerable length with Armature Winding Schemes, and Chapter VI. with the estimation of the various losses ; both of these are excellent. The rules for dynamo design are set forth in Chapter VII. They should offer no difficulty to the reader with practical experience. The reader without such experience will be reminded from time to time of the necessity of the warning given in the opening chapter. For example, on page 147 he is told to assume a suitable value for the Steinmetz co-efficient. Now this may vary by about 300 per cent. in different types of machine, and the reader who requires it will receive a salutary warning of the fact that his progress will necessarily be blocked from time to time unless he can fall back upon the practical experience of himself or others. The concluding chapter contains examples of dynamo design, selected from the most recent machines of leading makers. A series of useful tables and schedules, followed by a very complete index, brings the work to a conclusion.

"ELECTRICAL ENGINEERING MEASURING INSTRUMENTS." By G. D. Aspinall Parr. (Blackie & Son.) Price 9s. net.—This is a useful volume on a branch of electrical engineering which has hitherto been comparatively neglected by the makers of text books. The author very sensibly excludes any consideration of instruments which are merely of historical interest, and confines his attention to the description of those which are in general use at the present time. After a chapter dealing with classification and other general considerations, Chapters II. to V. are devoted to the description of the various commercial types of ammeters, voltmeters and wattmeters. Chapter VII. deals with Lord Kelvin's standard balances, the potentiometer, and a few other miscellaneous instruments. Chapter VIII. deals with electricity supply meters, and the work concludes with an excellent index. The volume is copiously illustrated, and a good feature is that the illustrations, for the most part, really explain the construction of the instruments, only a comparatively small percentage being of the only too common trade catalogue type.

"A TREATISE ON ZOOLOGY." Edited by E. R. Lankester. Part I., Introduction and Protozoa, 2nd fasc. By Messrs. Farmer, Lister, Minchin and Hickson. (London: A. & G. Black. 1903.) Pp. vii + 451. Illustrated.—Owing apparently to the vast amount of additional matter which had to be included as the result of recent discoveries, the editor has found it necessary to sub-divide the first part of this most valuable work into two sections, of which the second is now before us. And before going further we may candidly say that it is an utter impossibility to do anything approaching justice to a volume so teeming with new and interesting facts within the limits of space possible in this journal. As indicated by its title, the volume is devoted entirely to the lowest forms of animal life. It opens with an admirable dissertation by Dr. Farmer on the nature of the organic cell, in the course of which it is shown that, although this constituent of organised beings was discovered so long ago as 1665, yet that it was not till a couple of centuries later that its prime importance was recognised ; attention being at first concentrated on the cell-wall rather than on the cell-contents. The Foraminifera fell to the lot of Mr. J. J. Lister, whose name is a sufficient guarantee as to the manner in which they are described ; and Dr. Hickson's treatment of the Infusoria cannot but commend itself to all those interested in these lowly organisms.

The great interest of the volume is, however, undoubtedly concentrated in Prof. Minchin's admirable account of the Sporozoa (a name probably unfamiliar to the majority of our readers), not from its being in any way superior to the other sections, but from its containing such a large portion of entirely new matter. His account of the connection between malaria and mosquitoes, and of the malaria parasite (for it is of these and other parasitic organisms that the chapter treats), is, we believe, the first that has appeared in a general (we cannot say a popular) natural history in this country, and therefore gives to this volume a very special interest. Although we cannot attempt any survey of the contents of this chapter, we may direct attention to one or two of the most marvellous facts. A malaria-breeding mosquito when it sucks the blood of an infected human being, swallows the parasite in all stages of its existence ; but all stages, save the fertile "gametocytes," are unable to resist the action of the gastric juices, and continue their development. On the other hand, if the biting insect be a *Culex* instead of an *Anopheles*, all stages of the parasite are digested. But *Culex* is the intermediary for bird-malaria, and when an infected bird's blood is sucked, the gametocytes survive the digestive process ; the *Culex*, in fact, standing in the same relation to the bird malarial parasite as does *Anopheles* to that of man. It may be added that there is an idea as to *Anopheles* becoming immune to the malaria-parasite, which, if well-founded, may be the possible cause of the extinction of malaria in the Fens.

The volume, although of necessity extremely technical, is teeming with interest, and fully maintains the high level of its predecessors in appearance (although not in serial order)—and this is saying a very great deal.

"THE BOILING LAKE OF DOMINICA." By F. Sterns-Fadelle, B. ès sc. (Dominica.)—If the writer's science is a little out of date, and his language occasionally stilted, he has, nevertheless, produced a popular and interesting account of the discovery and appearance of the extraordinary boiling lake of Dominica, a phenomenon which remained unknown, even to the inhabitants of the island, until so late as March, 1875.

BOOKS RECEIVED.

Mostly Mammals. By R. Lydekker. (Hutchinson.) Illus. 12s. 6d.

The Wonderful Century. By Alfred Russel Wallace. (Swan Sonnenschein.) Illustrated. 7s. 6d net.

Ancient Calendars and Constellations. By the Hon. Emmeline M. Plunket. (Murray.) Illustrated. 9s. net.

Introduction to Nature Study. By Ernest Stenhouse, B SC. (Macmillan.) Illustrated. 3s. 6d

History of Philosophy. By William Turner, S.T.D. (Ginn) 12s. 6d.

Mysteries of Mithra. By Franz Cumont. (Kegan Paul.) 6s. 6d. net.

Elementary Geometry, Practical and Theoretical. By C. Godfrey, M.A., and A. W. Siddons, M.A. (Clay.) 3s. 6d.

The Moon, considered as a Planet, a World, and a Satellite. By James Nasmyth, C.E., and James Carpenter, F.R.A S. (Murray.) Illustrated 5s net.

Agriculture for Beginners. By Charles William Burkett, Frank Lincoln Stevens, and Daniel Harvey Hill. (Ginn.) 3s. 6d.

Hypnotism. By J. Milne Bramwell, M.D , C.M. (Richards.) 18s. net.

Principles of "Open-Air" Treatment of Phthisis and of Sanatorium Construction. By Arthur Ransome. (Smith, Elder.) 5s.

The Naturalist in La Plata. By W. H. Hudson, F.Z.S. (Dent.) 5s.

Swain School Lectures. By A. Ingraham. (Kegan Paul.) 5s. net.

A New Geometry for Schools. By S. Barnard, M.A., and J. M. Child, B.A. (Macmillan.) 4s. 6d.

First Stage Practical Plane and Solid Geometry. By G. F. Burn, A.M.I.M.E. (University Tutorial Press, Ld.) 2s.

Water, Dust and Heat. By G. Slade. (Passmore & Alabaster.) 1s.

Turner on Birds. Edited by A. H. Evans, M.A. (Clay.) 6s. net.

Shambles of Science. By Lizzy Lind Af Hageby and Leisa K. Schartau. (Bell.) 1s. 6d. net.

Electrical Installations. Vol. V. By Rankin Kennedy, C.E. (Caxton Publishing Co.) 9s. net.

Journal of the Anthropological Institute. January to June, 1903. 10s. net.

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TIRERRILL AND DRUMAHAIR.

By Grenville A. J. Cole, M.R.I.A., F.G.S.

The names of these two baronies are delightful, however corrupt they may be in their present form and spelling. Meeting on the borders of Sligo and Leitrim, Tirerrill and Drumahair occupy a country that is purely Irish, purely western, and yet is among the neatest and most attractive. You may leave Dublin in the morning and be in the midst of it long before noon; and then you will certainly desire to stay there and explore the ridges day by day. Lough Gill bounds the area on the north; and beyond rise the great scarps of limestone that shut it off from the sea at Donegal.

There is something fantastic in the landscape as we alight at the little station of Collooney, or of Ballysadare, on the main line to Sligo. A band of singular hills, knob-like and excrescent, runs into the south-west and is continued north-eastward as far as Manorhamilton. A fairly level lowland divides them from the sea, but from this rises the huge outlier of Knocknarea, crowned by its cairn, its sides almost vertical beneath a grassy dome. Not far east of it is Sligo, set more beautifully, perhaps, than any city in our islands, but showing little of its individuality from the level of the railway. There are some places that should be approached with deliberation; and Sligo certainly cannot be realised, unless one comes over the last hill from Ballysadare and looks across the roof-tops to Benbulben and the broken cliff-wall of Glencar. Away on the left a blue sea stretches, and, after a little time, we grasp the fact that those cloud-like masses beyond it, twenty-five miles away, are the highlands of Donegal.

Cities, however, are not to the purpose in the present article. We may go east at once into Tirerrill. One of the odd and rocky bosses faces us as we climb from Ballysadare; it is clothed below with woods of larch and fir, and shows on its higher slopes bare rounded surfaces of white or warm pink-brown. We touch the same rock beside the roadway in Glennagoolagh, above Ballydawley Lough, where we look south from the ridge into a more fertile lowland, backed by high Carboniferous masses in the region of Lough Arrow. Our ridge, in fact, is formed of granitoid rock, running across a Carboniferous country. North-west of it, the limestone type prevails, giving us scarps and precipices worthy of the boldest parts of Yorkshire; south-east of it the beds dip under the higher series of shales and sandstones, which even bear coal, on heights of thirteen hundred feet and upwards, in the cloud-swept country round Lough Allen.

The granite nowhere cuts the Carboniferous strata. On the contrary, these abut against it without a sign of alteration, or along a faulted junction that masks their true relations. We have here to deal with a portion of that older Ireland which formed a floor for the Carboniferous sea; our ridge was at one time a long promontory or island, until it became entirely submerged. By its powers of resistance, it has again asserted itself during the prolonged denudation of the country; while in places the stratified rocks have slipped down fault-planes from its flanks, and have given it thus a greater prominence in the landscape.

We may call the rock of this old axis a granite, but it varies considerably from point to point. On the charming wooded slope above Ballydawley Lough, it shows strong bands formed of lighter and darker groups of minerals; it is, in fact, a banded gneiss. Black mica gleams in abundance along one layer, accompanied by green pyroxene and beautiful clear brown garnets; quartz and various felspars form another layer; while here and there a great vein of quartz runs up along the general banding. In some places a patchy appearance presents itself; and soon we find whole lumps of foreign rock embedded in the granitoid gneiss. These are dark green and rich in hornblende; they weather away more rapidly than their surroundings, and thus come to lie in hollows of the gneiss, while the banding of the gneiss itself runs round them, and is emphasised where they happen to be most abundant.

These dark inclusions were first noticed by Mr. Hardman, and are well described, though not explained, in the memoir of the Irish Geological Survey on the district. Their interest lies in the fact that they must be older than the rock in which they are embedded. From our modern standpoint, we may agree that the gneiss is an old igneous mass, that penetrated some arch in the earth's crust in pre-Carboniferous times. In the lumps of hornblendic rock, technically called compact diorites and amphibolites, we have a relic of the rocks forming the arch, rocks much older than the granite which was forced among them.

This slope in Glennagoolagh gives us, then, one of those visions into the inner workings of the crust which charm us by their very incongruity. Back and back our thoughts may lead us, till we see the molten mass, heaving with its imprisoned water, and its components that would be gases if they could, oozing against the rocks that bound it, and constantly enlarging its borders by melting off fragments from the walls. Study of other districts shows that amphibolites and pyroxenites, rocks rich in minerals of the hornblende-augite group, can develop from a number of materials, when these are attacked by a granite magma; the altered and crystallising masses are, moreover, likely, under the same influences, to give rise to a profusion of garnet. Hence our inclusions of amphibolite, which we shall meet in greater variety as we go eastward, may represent a whole series of pre-existing rocks, many of them originally igneous, some of them argillaceous, and some calcareous, like the blocks of intensely metamorphosed limestone found in the ancient crater of Vesuvius.

What, then, is the banding of the gneiss but a record of the flow of the viscid granite magma? The pressure under which it flowed helped to arrange each constituent as it was formed, and perhaps even distorted and broke some crystals that had consolidated in a resting stage, and then were moved again. The structure in the ridge is essentially that of a mass forced onward even while it cooled; and the included blocks are often dragged out, until their longer axes lie along the planes of flow.

More than this, we soon become aware that the strongly banded and darkened gneiss of Glennagoolagh is by no means typical of the ridge. The true rock appears to be a pale fine-grained granite, consisting of quartz and felspar, with a trace of mica here and there. It is this that provides the beautiful white slabs which shine high up on Slieve Daeane amid the heather. But, wherever dark inclusions of foreign matter occur, the rock also becomes full of black mica and other dusky minerals, while even its lighter layers are found to contain brilliant little garnets. The microscope helps us to trace these garnets to the included blocks, and we soon see how the invading rock has become enriched at the expense of earlier masses.

Specimens can be found, measuring some two feet in each direction, which would serve as museum records of these subtle processes of admixture; but it is the broad survey, and the actual tramp across the hills, that force the conclusions on us, when we come to compare observations made many miles apart. And the story of the townlands along Lough Gill is found to be that of the whole of Donegal, and doubtless of many other parts of western Ireland—the story of the invasion of an ancient and already altered sedimentary series, containing sheets of

basic igneous rock, by a singularly pure granite magma, which became locally modified in its ascent.

We know of no rocks in Ireland older than the invaded series; but clearly they were laid down under ordinary conditions along a shore. We have nothing left of them in Tirerrill and Drumahair except the fragments in the gneiss; but farther north or south their bedded nature is unmistakable. One of the critical areas is that above Lough Nafooey, in the County of Galway, where Upper Silurian (Gotlandian) conglomerates contain fragments of the old series, and of a granite also. The granite of southern Galway has not penetrated these Gotlandian beds, though it has highly altered the underlying series of quartzites, schists, and limestones. In other parts of Ireland a granite of similar type has come up along the axes of Caledonian folding, that is, in earliest Devonian times, and has baked and altered the Silurian rocks. Since our ridge in Sligo and Leitrim, continuing the axis of the Ox Mountains, runs parallel with the Caledonian folds, we are left with an open mind as to whether the granite is a very old one remoulded by the Caledonian movements, or an early Devonian one, contemporary with the Leinster Chain.*

The road from Ballydawley Lough mounts along the south side of the ridge, and the Carboniferous rocks are exposed on our right in little cliffs and quarries. Castle Dargan stands characteristically on a sheer rock above a lake, one of the strongholds which, in this remote district, have an Irish rather than an Anglo-Norman history. Over there in the south, in the passage of the hills beyond Keishcorran, the army of the elder Essex went down before the organised clansmen; away east at Enniskillen there is still a certain cleavage between the older races and the newer settlers, who bravely defended what they won. On the north, again, is that delightful folk in Donegal, still speaking Gaelic, a language probably forced upon them by some far-off Celtic overlord. There is no body of men who can be presumed to be primordial in any territory, and least of all in Tirerrill and Drumahair, where the surge of battle has swept, ever since the stone-age, across the highland-border from the plain. Whose are these long stone graves upon the summits, ruined and lichened over before the days of O'Donnells and O'Rourkes? Irish or pre-Irish, they did their best to leave a memory, and were buried where they looked down southward from the hills they called their own.

And we now climb up past them, past the clean white cottages, with their little flower-gardens, set amid bosses of bare rock, till we come to the townland of Correagh, where we pass from Sligo into Leitrim. A green hollow stretches down towards Lough Gill, like a trench cut across the ridge; in old times the upper part of it was occupied by a lake, the alluvial clay of which forms meadow-land between the rocks. Lower down, we see that the whole valley depends on the presence of a great dyke of serpentine, which has weathered away, leaving in places a vertical wall of gneiss upon its flank. The outlet of this valley upon the wooded margin of Lough Gill is one of the surprises of a land where discoveries seem waiting to be made. Perhaps you may find, on some clear spring morning, the blue water lapping in sunlight round the islands, and the grey crags to northward ledged with newly-fallen snow.

The gneissic banding of the ridge is magnificently shown on the smooth glaciated surfaces, as we continue along the upland road to Crossboy School. All through this region we find pyroxenites with garnet included in and modifying the igneous invader. Then we pass on to the grass land of the Carboniferous Limestone, the high masses, with scarps and tables, and cliff-set dales like those of Derbyshire, forming a broken background beyond the village of Drumahair. Neglecting the easier route up the Bonet River, we gain the finest contrasts of the country on the old road over the shoulder of Benbo. Lough Gill with its islands stretches from our feet to Sligo city; the great dome of Knocknarea stands like a fort against the white gleam of the Atlantic, and the woodland climbs towards us from the hollows, breaks into a few stunted fir trees, and vanishes altogether on the grey-green limestone highland.

The constant washing of these upper slopes has produced at one point a singular brown "coral soil." The limestone has been dissolved away, leaving a mass of coral branches, and a few encrinite stems, as a residue. The fossils stand out also on the exposed surfaces of the rock; while above rises the heather-clad slope of Benbo, part of the gneissic axis against which the limestone rests. On the bold descent to Manorhamilton, our interest again passes to the gneiss, and the phenomenon of the inclusion of blocks of amphibolite is well seen along the streams. From this point we may turn back to Sligo through Glencar; or make for the Donegal border across the fine passage of Glenade; or go east to the lake-country of Enniskillen, seeing on the way those two Loughs Macnean, which here are taken for granted, but which would be the fortune of any English county. Close to us now, the Shannon rises, under the sandstone scar of Cuilcagh, and its long course, through chains of lakes, fitly divides this wilder Ireland from the east.

* *See* "The Backbone of Leinster," KNOWLEDGE, December, 1902.

MICROSCOPY

Conducted by M. I. CROSS.

NUMERICAL APERTURE AND RAPIDITY.

By A. E. CONRADY, F.R.A.S., F.R.M.S.

THE "numerical aperture" by which microscope objectives are usually characterized, and the "rapidity" which is marked on ordinary photographic objectives, obviously have some relation to each other, for both increase with the diameter of a lens. The precise nature of this relation is, however, not generally known; the consequence being that the microscopist who uses a rapid photographic lens for low-power work wonders in vain what "numerical aperture" the instrument possesses, and what resolving power he may reasonably expect from it, whilst the photographer who takes to photomicrography is similarly left in the dark as to the "rapidity" of his complicated apparatus, although that knowledge would be most useful to him in determining the time of exposure required. The following explanation should therefore be acceptable:

As the rapidity of photographic lenses is usually expressed by f-ratios, such as $f/8$ or $f/16$, we will set our formula to give these ratios, their meaning being that the marginal rays from the lens *converge* at the *rate* of 1 in 8 or 16, or whatever the f-value may be, or at the same rate as those from a simple thin lens of 1 inch diameter and 8 or 16 inches focus. Mathematically the f-value is therefore determined as the number of times the diameter of the cone of rays, taken at any point, is contained in the distance from that point to the apex of the cone.

We will now consider a microscope with an objective of known numerical aperture, *n.a.*, and arranged to give a known magnification $\times m$. The task set us is to find the convergence of the marginal rays on leaving the instrument.

Let the marginal ray from the object to the lens form an angle α with the optical axis; and let the same ray, on leaving

the instrument, form an angle β with the optical axis. Then we have, according to Abbe's sine-condition,

$$\frac{\text{sine } \alpha}{\text{sine } \beta} = m.$$

But, according to Abbe's definition, sine α is equal to $n.a.$, therefore

$$\frac{n.a.}{\text{sin. } \beta} = m;$$

or, transposed,

$$\text{sin. } \beta = \frac{n.a.}{m}.$$

Bearing in mind that the pencils leaving the microscope are always very slender ones, and β, therefore, so small an angle that its sine and tangent may be considered as equal to each other, we can say

$$\text{Sin. } \beta = \frac{\textit{Radius} \text{ of cone of rays}}{\text{Distance to apex}}.$$

We had previously defined the f-value as the ratio

$$\frac{\text{Distance to apex}}{\textit{Diameter} \text{ of cone of rays}}.$$

A comparison of these two ratios gives us at once

$$\text{I. } f\text{-value} = \frac{1}{2 \text{ sin. } \beta} = \frac{1}{2\frac{n.a.}{m}} = \frac{m}{2 \times n.a.}$$

or, in words—

The f-value is found by dividing the total magnification by twice the n.a.

We soon see that the rapidity is generally exceedingly small, for, taking a typical example, say, $n.a.$ ·7, magnification 350, we get

$$f\text{-value} = \frac{350}{2 \times \cdot 7} = \frac{350}{1 \cdot 4} = 250;$$

or, in photographic language, the microscope in this case works at $f/250$.

Of course, this low rapidity is the cause of the long exposures required, and of the difficulty experienced in focussing the image on ground glass.

In the above argument we have shunned the question as to what trigonometrical function is involved in this question of rapidity, but if we stipulate that the f-values shall be such that their squares are inversely proportional to the intensity of the illumination, the general formula used above, $\frac{\text{sine } \alpha}{\text{sine } \beta} = m$, decides the question, for as all the light which the object sends into the objective is reunited in the image, but spreads over an area of m-times the diameter, the intensity of illumination of the image is $\frac{1}{m^2}$ that of the object, or the f-value or the side of the image should be m-times that on the side of the object to conform to the desired proportionality, or in the same proportion as $\frac{\text{sine } \alpha}{\text{sine } \beta}$. Hence the f-value is or should be the reciprocal of twice the *sine* of the angle of convergence, and our formula may be used for any convergence, although originally derived for small angles. It follows that the f-value of a microscope-lens on the side of the object, or as used for micro-photography, is correctly found by our formula $= \frac{1}{2 \times n.a.}$.

This formula shows that, from this point of view, microscope-lenses are exceedingly rapid, for a low-power lens of $n.a.$ ·25 has a rapidity of $f/2$, equal to the fastest portrait lenses. It also shows that a dry lens (*i.e.*, $n.a.$ not more than 1) cannot possibly be faster than $f/\cdot 5$.

We will finally consider the photographic lens used for microscopical purposes and determine its $n.a.$ from the known f-value. The latter is always stated for the principal focus, whilst we are going to use the lens at longer conjugates. If we assume that the lens behaves like a thin lens of the same equivalent focus, the f-values will change proportionately to the conjugates. For magnification $\times\, m$ these latter are respectively $(m+1)f$ and $\frac{m+1}{m}f$. The resulting numerical aperture is, therefore,

$$\text{II. } n.a. = \frac{1}{2 \times \frac{m+1}{m} f\text{-value}} = \frac{m}{2 \times (m+1) \times f\text{-value}}$$

or, in words—

The numerical aperture of a photographic lens used for photomicrographical purposes is found by dividing the magnification by the product of twice the f-value and one plus the magnification.

Thus a lens working at $f/6$ and magnifying, say, four times has a numerical aperture

$$= \frac{4}{2 \times 5 \times 6} = \frac{4}{60} = \frac{1}{15} = \cdot 067.$$

The formulæ I. and II. solve the problems defined in the introduction to this article in every possible case; they can even be used in the case of immersion-objectives, for the above deductions apply to these lenses if we substitute n. sine α for sine α, n being the refractive index of the immersion-fluid.

THE COLLECTION, EXAMINATION, AND PRESERVATION OF MITES FOUND IN FRESH WATER (*Hydrachnidæ*).

By Chas. D. Soar, F.R.M.S.

(*Continued from page* 212.)

On reaching home the contents of the bottle should be emptied into a porcelain dish such as photographers use, when it will be noticed that the mites generally swim in the corners or along the sides, and can then be removed with a pipette to a large tube filled with clean water in which some *Anacharis* is placed. This latter will keep the water clean and fresh for a considerable time.

Experience will dictate which species can safely be kept together, a matter in which some discrimination is required, because some varieties prey on others, such, for instance, as *Limnesia* on *Eulais.*

Undoubtedly the best plan is to proceed with the examination at once, because a great part of the brilliancy of colouring is lost in a short time, and the mites are much more lively when freshly caught than subsequently. I have, however, kept mites alive in a tube 4 in. by 1 in. by adding fresh water to replace that evaporated, for a period of twelve months.

The best method of examination is to place the mite on a 3 in. by 1 in. glass slip, turning the specimen on the ventral or dorsal side as may be required, and having every part extended. A cover-glass is then laid over the specimen, and sufficient clean water is allowed to flow between the cover-glass and the slip to fill the intervening space. The specimen may move its limbs and palpi for a short time, but it soon becomes quite passive, the weight of the cover-glass being sufficient to retain the body of the mite in position. The slip is then laid on a piece of white card on the stage of the microscope, and illuminated by reflected light; a $1\frac{1}{2}$ in. objective will usually be found the most suitable.

The advantage of this arrangement is that the specimen can be reversed, and both sides examined, and by having an aperture in the cardboard, a further examination may be made by transmitted light. In this latter condition the hairs and claws can be seen very distinctly, particularly if the light be thrown a little obliquely. After examination the specimens can be returned to the tube, and are usually none the worse.

To preserve the specimens they should be placed in the following solution:—

10	parts	glycerine
10	,,	distilled water
3	,,	citric acid
3	,,	pure spirit.

They can be placed in the solution alive, and although at first the limbs will be contracted, they subsequently retract. It also preserves the colours of hard-skinned mites fairly well.

If at any time it is desired to make a mounted preparation of any mites preserved in this way, they can be transferred to cells containing the same solution. If required for balsam mounts, the glycerine can be removed by repeated soaking in absolute alcohol, subsequently passing them through clove oil.

It will be found that balsam-mounted specimens will have a tendency to vaporize; this can be obviated by making a small hole in the body of the mite in a position which is of no consequence, and thus allow the balsam to penetrate. I think the soft-skinned mites mount best in glycerine solution; I do not mount in this medium myself, but have some beautiful preparations by Mr. Taverner, in which the construction is shown to the best advantage. They have been in my possession for some time, and show no signs of deterioration.

Should any readers take up the study of these beautiful creatures, dates of collecting, localities where discovered, and particulars of anything they may have observed new in the life-history, particularly varieties of colouring, should be carefully kept, together with, if possible, drawings. There is one mite, *Piona rufa Koch*, which has been found in England in three distinct bright and beautiful colours, viz., red, green and brown.

The two best text books on fresh-water mites are in German —"Deutschlands Hydrachniden," by Dr. R. Piersig, rather an expensive work, with about 500 pages of letterpress and 51 plates; and a number of "Das Tierreich" on the *Hydrachnidæ*, by Dr R. Piersig, Berlin, 1901. This contains the account of every known species up to date of publication.

Lectures and Demonstrations in Microscopy.—One of the rules of the Manchester Microscopical Society states that—"The objects of the section (Extension Section) shall be the extension of the knowledge of Microscopy and Natural History to outside associations by means of lectures and demonstrations."

In pursuance of the objects set forth, this Society has prepared a list of fifty-four lectures and demonstrations of various microscopical subjects, some of which are illustrated by diagrams, others by magic lantern, the microscope, or by actual specimens, while in some instances two or more of these are combined.

The work of lecturing and demonstrating is entirely gratuitous on the part of the members, the only charge made being for the hire of slides, travelling and out-of-pocket expenses, and in some cases an additional small fee for the lecture. This is specially intended to present scientific knowledge in a popular form before societies which are unable to pay large fees to professional lecturers.

This is a step which it is hoped will meet with great appreciation, for it is undoubtedly in the right direction, and should increase the popularity of the microscope.

Full particulars may be obtained from Mr. Abel P. Bradshaw, 3, Clifton Street, Hulme Hall Lane, Miles Platting.

Practical Scheme.—Through the kindness of a naval officer in China, I am able to offer for distribution some spines of *Echinus*.

The following is the manner in which he suggests they should be ground and mounted: Slice the spine as finely as possible with a fret-saw, dressing the cut end after each slice with a file; cement a number of slices to a slip by their smoothed sides, with balsam, in the usual way. Rough them down with a smooth file and a light hand, polish on a stone with water, turn and finish on the other side with the stone, select the best specimens, and mount in balsam.

I shall be happy to send some of these spines to any readers who will send a stamped addressed envelope, together with the coupon which appears in the advertisement pages of this issue.

NOTES AND QUERIES.

A. R.—You will get your unmounted microscopic objects from Mr. R. G. Mason, of 69, Clapham Park Road, S.W. He has a large variety put up in packets, with full directions for preparing.

C. Mostyn.—It would appear that a mistake was made in your lamp in the size of slip. It is not unusual for lamp chimneys to be provided with apertures of different sizes and shapes, so that light may be only emitted from one definite spot, and the room kept otherwise dark. You will probably have noticed in the July number of this journal that Mr. Rousselet offers suggestions as to the selection of objectives for Pond-Life, which exactly accord with your ideas.

C. J. S.—The only way to remove picric acid is to wash in repeated changes of methylated spirit; the specimens must not go into water at all, and the staining should be carried out in alcoholic solutions. Chromic and osmic acid solution sections wash well in water, they should then be placed in a 10 per cent. solution of bicarbonate of soda for about an hour, wash in water thoroughly to remove all trace of soda, then place in methylated spirit, which should be changed every day until water is removed. Three changes are usually required.

Communications and enquiries on Microscopical matters are cordially invited, and should be addressed to M. I. Cross, Knowledge *Office*, 326, *High Holborn, W.C.*

NOTES ON COMETS AND METEORS.

By W. F. Denning, F.R.A.S.

Brooks's Periodical Comet (1889 V.—1896 VI.).—This comet was first discovered on July 6, 1889, and kept well under observation during the ensuing summer and autumn. At the end of the month named it appears to have broken up into several distinct portions, for it was thus observed at the opening of August. A period of 7·07 years was found for the time of revolution, and it duly returned in 1896, on which occasion it was first seen by M. Javelle, of the Nice Observatory, on June 20, and the comet passed its perihelion on November 4. From the observations obtained, Herr Bauschinger redetermined the period as 2592·137 days, or 7·096 years. For the present return Mr. F. E. Seagrave has computed an ephemeris, and finds that while the comet made its nearest approach to the earth at the middle of August, the perihelion will not occur until December 11. Prof. Aitken, of the Lick Observatory, redetected the comet on August 18, and found it in a position closely according with the ephemeris place. It is a faint object, moving slowly eastwards low in the southern sky. The following is an ephemeris for Washington, midnight:—

Date.	R.A. h. m. s.	Dec. ° ′	Distance in Millions of Miles.
October 4	20 45 39	−24 32	129
" 8	20 48 37	−24 0	131
" 12	20 52 4	−23 26	133
" 16	20 55 59	−22 51	136
" 20	21 0 18	−22 14	139
" 24	21 5 2	−21 35	143
" 28	21 10 9	−20 54	147

August Meteors.—The moon was full on August 8, and interfered in no small degree with observations of the Perseid shower. The unfavourable weather of a very ungenial season added to the difficulties, and thus comparatively few meteors were observed. The night of August 10 was, however, clear at Bristol, and the Perseids returned, though by no means abundantly, shooting from the usual radiant about 2° N.N.E. of η Persei The maximum evidently occurred on the night of August 12, Perseids being very plentiful, and falling from a radiant very sharply defined at 46° + 58°. On the latter night, Prof. Herschel, at Slough, saw about 25 meteors during a three hours' watch, and found the chief radiants at 41° + 58° and 49° + 61°, with indications of others in Camelopardus, while only two meteors belonged to the minor showers of the epoch.

Duration of the Perseid Shower.—A few swift meteors leaving streaks continued to be observed this year until August 25, and as they were conformable, both in aspect and direction of flight, with true Perseids, it seems highly probable that the shower remains visible until the date named. Observations in previous years have also furnished distinct evidence of Perseids in the fourth week of August. The radiant point on August 25 appears to be in about 68° + 59°, but the position is not very precisely defined, the meteors having nearly all appeared on the western side of the radiant. There are showers of Camelopardids in August, from 60° + 59° and 77° + 57°, the meteors of which are likely to be confused with, and mistaken for, true Perseids; it is therefore impossible to conclude with certainty that the great Perseid shower is visibly prolonged until August 25. More materials are required, and to obtain these it will be important to watch the northern sky between August 20 and 25 in future years, and record with particular care the flights of any streak-leaving meteors that may appear.

Brilliant Meteors.—On August 15, 10h. 44m., G.M.T., the Rev. W. F. A. Ellison, of Enniscorthy, observed a meteor equal to Venus. It gave several bright flashes and left a short train as it moved from 205° + 54° to 182° + 45°. On August 21, at 13h. 32m., a fireball was seen by the writer at Bristol. It produced a flash apparently as bright as the full moon, and left a streak of 5 degrees 1° to the right of β Cygni for about a minute. The path was from 295° + 30° to 285° + 25½°. The radiant cannot be definitely assigned as no other observations have come to hand. There was another fine meteor seen at Kirkstall at an early hour on the same morning, for a correspondent of the *Yorkshire Daily Post* alludes to it as shooting from "a little above α Andromedæ to the well-known 'W' of Cassiopeia." On August 29, 8h. 15m., a pretty bright meteor was noticed by Mr. F. L. Raymond at Yeovil, in the west, travelling rather swiftly from 210° + 35° to 190° + 20°.

Real Path of a Meteor.—On August 25, 9h. 35m., Mr. C. L. Brook, of Meltham, near Huddersfield, observed a meteor of 3rd magnitude shooting from 347° + 2½° to 341° − 8° in one second. The same object was seen by the writer at Bristol, where the apparent course was from 27° + 29° to 20° + 19°. It moved swiftly across α Trianguli, and left a streak. The combined paths indicate a radiant at 79° + 59°, and heights of 70 to 52 miles over Suffolk and Essex. This shower near β Camelopardi appears active in the months August, September, and October.

THE FACE OF THE SKY FOR OCTOBER.

By W. Shackleton, F.R.A.S.

The Sun.—On the 1st the sun rises at 6.0 and sets at 5.39; on the 31st he rises at 6.51 and sets at 4.35.

Sunspots and faculæ may frequently be observed on the solar disc.

The Moon:—

	Phases.	H. M.
Oct. 6	○ Full Moon	3 24 P.M.
„ 13	☾ Last Quarter	7 56 P.M.
„ 20	● New Moon	3 30 P.M.
„ 28	☽ First Quarter	8 33 A.M.

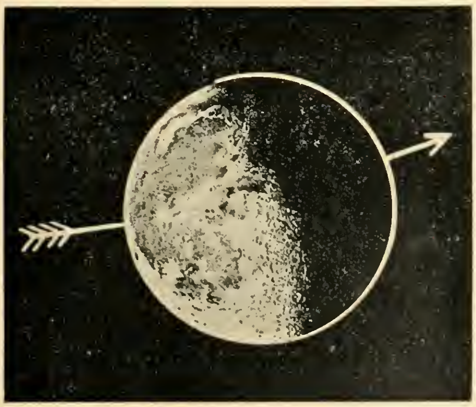
The moon is in perigee on the 16th, and in apogee on the 28th.

There is a partial eclipse of the moon on the 6th, but as the moon at the time of rising has left the umbra and is well advanced into the penumbra, the phenomenon will scarcely be noticeable in this country. Some of the particulars are as follow:—

Moon rises at Greenwich		5.32 P.M.
Middle of Eclipse	Oct. 6.	3.18 P.M.
Last Contact with the Shadow ...	„	4.55 P.M.
Last Contact with the Penumbra	„	6.7 P.M.

Occultations:—

The somewhat rare occurrence of an occultation of a first magnitude star takes place on the 10th, when Aldebaran suffers occultation about half an hour after the moon rises; disappearance takes place at the bright limb, and reappearance at the dark limb, as shown in the diagram below:—



Occultation of Aldebaran, October 10.

Date.	Star Name.	Magnitude.	Disappearance. Mean Time.	Disappearance. Angle from N. Point.	Disappearance. Angle from Vertex.	Reappearance. Mean Time.	Reappearance. Angle from N. Point.	Reappearance. Angle from Vertex.	Moon's Age.
			h. m.	°	°	h. m.	°	°	d. h.
Oct. 6	ε Piscium	5·7	11 31 P.M.	55	62	12 48 A.M.	257	248	15 19
„ 10	α Tauri	1·1	8 18 P.M.	83	120	9 11 P.M.	257	296	19 16
„ 30	ρ Aquarii	5·3	7 10 P.M.	3	9	7 46 P.M.	311	310	10 4

The Planets.—Mercury is in inferior conjunction with the sun on the 3rd. Towards the middle of the month he is a morning star in Virgo, and on the 19th he is at a favourable morning elongation, attaining a separation of 18° 13′ W. from the sun, and rises at 4.42 A.M., or nearly two hours in advance of the sun.

Venus is a morning star in Leo, rising on the 1st at 4.28 A.M., and on the 31st at 2.51 A.M. She attains her greatest brilliancy on the 24th, the disc then having a diameter of about 39″, and a little more than one-fourth being illuminated, thus answering to the moon five days old.

Mars is practically unobservable, being very low down in the south-west shortly after sunset.

Jupiter is in a most convenient position for easy observation, being on the meridian on the 1st at 10.32 P.M., 15th at 9.32 P.M., 31st at 8.26 P.M., and having an altitude of about 31°. About the middle of the month the polar and equatorial diameters are 45″·3 and 48″·4 respectively. Jupiter is near the moon on the evenings of the 4th and 31st.

The configurations of the satellites as seen in an inverting telescope at 9.30 P.M. are as follow:—

Day.		Day.	
1	4 3 2 ○ 1	17	4 ⊙ 2 3
2	4 ○ 3 2 ●	18	4 2 ○ 1 3
3	4 1 ⊙ 3	19	4 1 ○ 3 ●
4	4 2 ○ 1 3	20	4 3 ○ 1 2
5	1 4 ○ 3 2	21	3 4 1 2 ○
6	3 ○ 1 2/4	22	3 2 ○ 4 1
7	3 2 1 ○ 4	23	1 3 ○ 2 4
8	3 2 ○ 1 4	24	⊙ 2 3 4
9	● ○ 3 2 4	25	● 2 ○ 3 4
10	1 ○ 2 3 4	26	1 2 ○ 3 4
11	2 ○ 1 3 4	27	3 ○ 1 2 4
12	1 ○ 3 4 ●	28	3 1 2 ○ 4
13	3 ○ 4 1 2	29	3 2 ○ 1 4
14	3 2/1 4 ○	30	1 3 ○ 4 2
15	4 3 2 ○ 1	31	4 ○ 1 2 3
16	4 1 ○ 2 ●		

The circle (○) represents Jupiter; ⊙ signifies that the satellite is on the disc; ● signifies that the satellite is behind the disc, or in the shadow. The numbers are the numbers of the satellites.

Saturn is on the meridian about $1\frac{1}{2}$ hours after sunset; although rather low down he well repays observation. He is stationary on the 8th, after which his motion is again direct or easterly. About the middle of the month the diameter of the ball is 16″, whilst the diameters of the outer major and minor axes of the outer ring are 40″ and 14″ respectively; we are looking down on the northern surface of the ring at an angle of 20°, it therefore appears widely open.

Uranus is practically out of range, being very low down in the south-west, and setting shortly after sunset.

Neptune rises about 9.45 P.M., at the beginning of the month; he is situated in Gemini near the star μ, as shown on the chart given in the January number.

The Stars.—About 9 P.M., at the middle of the month, the following constellations may be observed:—

Zenith .	Cygnus, Cepheus, Cassiopeia.
South .	Pegasus, Aquarius, Capricornus, *Fomalhaut*.
West .	Lyra, Hercules, Ophiuchus, Corona; Boötes to the N.W.; Aquila to the S.W.
East .	Andromeda, Perseus, Aries, Pleiades; Auriga to the N.E.; Cetus to the S.E.
North .	Ursa Major, Ursa Minor, Draco.

Minima of Algol may be observed on the 7th at 10.25 P.M., 10th at 7.14 P.M., 28th at 0.8 A.M., and 30th at 8.56 P.M.

Chess Column.

By C. D. Locock, B.A.

Communications for this column should be addressed to C. D. Locock, Netherfield, Camberley, and be posted by the 10th of each month.

Solutions of September Problems.

No. 1 (H. N. Fellows).

1. Q to R2, and mates next move.

No. 2 (B. G. Laws).

Key-move.—1. R to Kt4.

If 1. . . . P × R,	2. Q to Bsq.
1. . . . P to B5,	2. R × P.
1. . . . K to B3,	2. Q to R4ch.
1. . . . B to Q5,	2. R to K4ch.
1. . . . Others,	2. Q to R6.

After 1. . . . P to B3, various continuations are possible.

Solutions received from "Quidam," 2, 4; "Alpha," 2, 0; W. H. S. M., 2, 4; T. Dale, 2, 4; W. Nash, 2, 4; G. W. Middleton, 2, 0; H. S. Brandreth, 0, 0; "Looker-on," 2, 4; C. Johnston, 2, 4; H. F. Culmer, 2, 4; G. A. Forde (Major), 2, 4; J. W. Dixon, 2, 4; F. L. Schneider (No. 1 only, too late to score).

"*Alpha*."—I am glad to hear that your change of abode will not prevent your continuing to solve the Knowledge problems. I should be sorry indeed to lose the most faithful of our solvers.

C. T. Blanshard.—The paper sent contained no notice of your Problem Tourney. Did you send the wrong number by mistake?

J. W. Abbott.—Many thanks for the two problems, which I shall be very glad to print shortly.

Solution of End-game.

After 1. R to B8ch, B × R (best) W. H. S. M. points out that White has the choice of two continuations, viz., 2. R to Kt8ch, K × R; 3. Kt to B6ch, etc., or 2. Q to R7ch, K × Q; 3. Kt to B6ch, etc.

SOLUTION TOURNEY.

Very little change has taken place among the relative positions of the leading solvers. The first ten are now:—

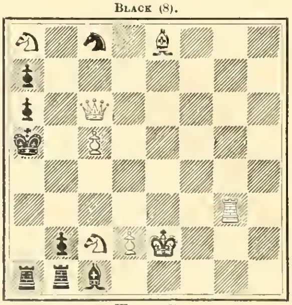
W. Nash	58	W. H. S. M. ...	54
"Looker-on" ...	58	G. W. Middleton	50
J. W. Dixon ...	58	"Alpha"	46
C. Johnston ...	58	H. F. Culmer ...	42
"Quidam"... ...	55	Major Forde ...	40

PROBLEMS.

By Philip H. Williams.

No. 1.

Black (8).

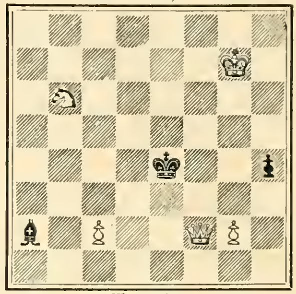


White (8).

White mates in two moves.

No. 2.

Black (3)



White (5)

White mates in three moves.

CHESS INTELLIGENCE.

The Amateur Championship Meeting at Plymouth was concluded early last month. The entry was more representative than has been usual of late years, and it was found necessary to divide the players into two sections, the first two in each section to decide the final order by means of a fresh tournament limited to themselves. The preliminary scores were:—*Section A:* Wainwright, 7; Bellingham, $6\frac{1}{2}$; Palmer, 6; Michell, $5\frac{1}{2}$; Mollard, 3; Lambert, $2\frac{1}{2}$; Parry, $2\frac{1}{2}$; Miss Finn, 2; Bowles, 1. *Section B:* Gunston, $7\frac{1}{2}$; Emery, $5\frac{1}{2}$; Alcock, $4\frac{1}{2}$; Mortimer, $4\frac{1}{2}$; Fawcett, 4; Jones, $3\frac{1}{2}$; West, $2\frac{1}{2}$; Dunstan, 2; Taylor, 2. In the final tournament the score was:—G. E. H Bellingham, 2; A. Emery and W. H. Gunston, $1\frac{1}{2}$; G. E. Wainwright, 1. Mr. Bellingham thus becomes Amateur Champion. The system in use does not seem altogether satisfactory; for instance, it seems decidedly hard that Mr. Wainwright, after coming out with a clear lead in probably the stronger section of the two, should have to be content with fourth place. A choice of three (instead of two) from each section, or a two-round final contest would certainly be a more satisfactory test.

A series of six games to test the soundness of the "Rice" Gambit was recently played at Brighton, Dr. Lasker offering the gambit in every game and M. Tchigorin conducting the defence. The result was a victory for the Russian master by two games to one, three being drawn.

Only three players competed for the Scottish Championship this year, Mr. D. Y. Mills being a prominent absentee. Mr. J. Borthwick came out first with a score of three, Mr. E. Macdonald winning two, and Mr. J. D. Chambers one.

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CONTENTS.

THE STRUGGLE FOR EXISTENCE IN SOCIOLOGY.

By J. Collier.

III.

The Political Struggle.

The political struggle is a continuation of the ethnical struggle in a new sphere and under new forms. It is that struggle transferred from without to within the State, and extended to all departments of public life. The invaders are no longer foreigners; they are citizens of the new country, and they gradually blend themselves with almost all its ranks. The invasion no longer takes place on the frontiers; its waves mount to the halls of the legislature, flow through the courts of justice, and flood the chambers of administration. The nature of the struggle is unchanged—warfare is a mere incident of it, as it is of the ethnical struggle, and plays no smaller and no larger a part in it; the method is the same—slow displacement and supersession, not destruction or extermination; and the result is the same—the infusion of a new element into the institutions of a people, as into its ethnical composition. Even the instruments are not essentially altered; laws, judicial decisions, and administrative regulations continue, as they began, the work of fusion, and are only applied to new cases.

Thus the history of ancient Greece was the after-reflection of the struggle between the immigrant Hellenes and the indigenous Pelasgians, Carians, or what not. The long conflict between the patricians and the *plebs* of ancient Rome was a continuation of the strife between the immigrant Romans and the indigenous Latins; and its various incidents, such as the election of tribunes and of a plebeian consul, and the enactment of agrarian laws, were at bottom of the same character as the acts of aggression and resistance that constituted the invasion and the defence. Augustin Thierry's view, that the racial struggle between the Saxons and the Normans is the key to the subsequent political history of England, has not been accepted by historians in its entirety; yet if we will define "race" historically instead of ethnically, and consider the "Saxon race" as consisting of a mass of Teutons and Northmen (thus so far resembling the "Norman race"), on a compound basis of pre-Aryans and Celts (such as Ethnology shows to have existed in England), and all because of historical association and antagonism to the invaders, animated by similar dispositions, we shall find his view to be sociologically sound. It may then be used to explain our political history. The Tories were, and the Conservatives are, sometimes of Celtic or Turanian origin, but they have assumed, where they did not naturally have, the sentiments of a governing aristocratic race. The Whigs were, many of them, hereditary aristocrats, and the Radical and Socialist leaders have often been cultured patricians. None the less, both associate themselves with the characteristic feelings of their parties, and reflect their pristine antagonisms. The history of France has likewise been written by its greatest historians as that of a conflict between the various races that have successively occupied the soil. From the fifth century to the thirteenth it consisted in the gradual taking possession by the Germanic invaders of all the institutions of public and social life; from the thirteenth to the eighteenth, in the slow recovery by the indigenes of their lost ground; while the revolution was the uprising of the Celtic and possibly the Turanian masses.

The Dynastic Struggle.

The succession of dynasties resembles the immigration of new species. Like them, they slowly take possession of their new area. It will be more instructive to describe a single such case in some detail than to make vague general references that would leave no definite impression. The Carolingian dynasty sprang up by the side of the Merovingian, insensibly gathered strength, and at last supplanted it. A strong power was needed to keep in order the noisy and tumultuous crowd of nobles who surrounded the Frankish kings. They themselves elected a Mayor of the Palace, or Lord Chamberlain, as they had once elected their sovereigns. The mayor had at first no other office than to compose their disputes, and thus relieve the king of an irksome duty. As they naturally appointed one of themselves, and probably their strongest man, he soon became their head. Possessing so much authority, he naturally became chief minister of the sovereign. He soon made his position impregnable. In 613, after a struggle between the nobles and the dynasty, one mayor stipulated that he should never be deposed, and extracted from the king an oath to that effect. The office was next made hereditary in a particular family, that of Pepin, which had acquired wealth and consideration. King Dagobert died, leaving an infant son. The mayor became

regent or working king. The infant died, and in 656 the mayor made his own son king. It was too soon. The usurper was dispossessed by the vigorous sovereign of rival Neustria, who annexed the kingdom. The victor died the same year, also leaving only infant sons. The Austrasian grandees then deserted the race that had proved unable to defend itself, and made their mayor Duke of the Franks. It was the first titular step to sovereignty. Power at home leads to self-assertion abroad, and the Mayor of Austrasia attacked the Mayor of Neustria in 687 and defeated him in a great battle near Péronne.

Pepin brought back with him to Austrasia the king of the vanquished people, but the Merovingian dynasty was practically at an end. It indeed lived on for 65 years longer, but as the mere shadow of a royal race. Most of the kings died in youth or were old men before they were thirty. They were known as the "do-nothing kings." They retained the long hair and beard that were the emblems of kinghood. They sat on a throne and received ambassadors, to whom they recited dictated speeches. Once a year they appeared at the assemblies of the warriors. Generally they lived isolated on a farm, enjoying a pension (very irregularly paid, we are told) assigned them by the mayor. Of the two last surviving kings of the two kingdoms, one voluntarily entered, and the other was confined in, a monastery.

Meanwhile, the Mayor of Austrasia steadily gained ground. The family of Pepin grew in wealth and in sanctity, and Pepin gained consideration by his equity. He built up the executive authority and kept the nobles in subjection. His famous son, Charles Martel, defeated the Saracens at Poitiers, and saved northern Europe from invasion. Charles's son, Pepin the Little, conquered Burgundy and Aquitaine. He was then strong enough, with the approval and aid of the Pope, to proclaim himself king in 752. The struggle had lasted 150 years.

There was no lack of battle in its primary sense, as we perceive; assassinations of rival kings, queens, and mayors were not infrequent; but the gist of the dynastic struggle did not lie there. It lay in the steadfast advance of a new and still incorrupt ethnical variety and the slow recession of a race that died, not only of defeat, but of its own internal decline. Nor does the defeat of a dynasty necessarily involve its extinction. It may live on, driven into a remote or an inferior habitat. The Dukes of Gascony or Aquitaine and the Counts of Armagnac in the fifteenth century were the lineal descendants of King Charibert in the seventh.

The Ministerial Struggle.

The advent of a new dynastic variety commonly brings with it a new administrative variety, which is of the same race with it, like the Guises and like Sully, or which moulds it in its own image, as the doctrinaires of the French Restoration moulded the Orleans dynasty. But it may also spring up in sympathy with a new type of sovereign, and then we observe in both cases the rise of an original species. Charles V., well named the Sage (1364-80), was a new kind of monarch in France. Staying at home, while his luckless predecessors had gone out to the disastrous fields of Crécy, Poitiers, and Agincourt, he recovered by diplomacy as much territory as they had lost by war, and governed the country like a "citizen king." His Ministers, disdainfully called "small people" and "the marmosets" by the nobles, had risen up from the wealthy and instructed upper middle class, and they ousted, by mere choice of the King, the royal princes and feudal nobles who had long misgoverned France. Driven from office at his death by the re-entrant seigneurs, they were replaced in it eight years later by the new King, his son, and for four short years they ruled the country with wisdom. Unhappily, the insanity of the King again led to their exclusion, and another feudal reaction ensued. In all this there was no encounter between the two bodies of Ministers; no victory and no defeat. It is true that the chief Minister of the "marmosets" was assassinated, but by a noble in personal revenge. A change of moral climate, so to speak, a return of the glacial epoch, as it were, made the continued existence of the new men impossible.

The first Bourbon king of France inaugurated, or revived, the modern type of Minister in the great Sully. Henry's strong personality survived his assassination, and kept the Minister in office for a while, but a new political atmosphere soon made him obsolete. The Italian Queen-mother initiated a foreign policy, involving a Spanish alliance, with which the Protestant could have no sympathy. His colleagues, Villeroy, Sillery, and Jeannin, kept their ground during the first phase of the regency, and then they too had to go. The "grey-beards" were replaced by the "young people"—Barbin, Mangot, Brienne, and Richelieu. Again there was no battle. An Italian favourite, Concini, had confirmed the new direction given to the policy of France, and, from Protestant and German, had made it Catholic and Spanish. There was no conflict between the new Ministers and the old. As Gabriel Hanotaux has observed, it was "the pressure of interests and events" that bore the new Ministers to office. The change of environment killed the old species and favoured the survival of the new. When Richelieu subjugated his colleagues, and reigned alone, or in company with the formidable Father Joseph, it was because his bold and original genius had created a new environment once more, and made French policy swerve back into the channel that Henry had dug for it. The deposition of this Minister or that was a mere incident of the struggle.

The rise and fortunes of the Doctrinaire Party have been narrated in the delightful *Souvenirs* of Duke Victor de Broglie, the worthy son-in-law of Mme. de Staël, who might perhaps be named the ancestress and spiritual founder of the party. It inherited her brilliancy and her rectitude. Guizot was its brain; Camille Jordan its heart; de Serre its orator; Broglie its cross-fertiliser; Barante its historian; and Charles de Rémusat its philosopher. Planted before the Restoration, it sprang into prominence in 1818. In the beginning of that year, though numerically "almost imperceptible," it elected the President of the Chamber, and before the end of the year it placed in office a Ministry that was called the Doctrinaire Ministry, because "the party was the nerve and brain" of the Ministry, though only one of its members was a Minister. Not till after the Revolution of 1830 did it form a Ministry of its own, and that lasted for little more than two months, but it may be said to have moulded the French legislature in its own image. We need not further follow its fortunes. Nor need we take too seriously the military phraseology in which the party struggle is described by the Duke, who had lived through the wars of the Republic and the Empire. The doctrinaire party was "a headquarters staff without soldiers"; it "planted its flag" in certain positions; it was "vanquished" on certain grounds; a system or a law was "keenly attacked"; a bill was "combated," and "during the height of the combat . . ."; and so on. The phrases do not deceive us; we are familiar with them in our own histories and journals; and no one who has witnessed an oratorical tourney in the House of Commons, especially in the great days of Gladstone and Disraeli, will underrate the element of battle in Parliamentary debates. It is assuredly an essential part of the Ministerial struggle in free countries;

but it is a secondary part. The primary and real struggle in France consisted in the incessant effort to propagate the new ideas, revealed in the lectures of Guizot, Villemain and Cousin at the Sorbonne; in the pamphlets of Benjamin Constant and the articles of Armand Carrel; in the poetry of Lamartine and the prophecies of Lamennais; and in the salon of the beautiful and intellectual Duchess de Broglie. There, and in similar quarters, was waged the true battle. In the political remoulding of the middle class and the foundation of constitutional government lay the victory. In the hopeless obsolescence of the *ancien régime* lay the defeat.

FAMILIAR BRITISH WILD FLOWERS AND THEIR ALLIES.

By R. Lloyd Praeger, B.A.

VI.—ORCHIDS.*

Of all the orders of British plants, Ferns and Orchids are perhaps the two which are most attractive to lovers of plant-life, either native or exotic. And just as the splendid Adiantums and Cattleyas of foreign climes form one of the chief interests of the cultivator under glass, so to the British student of nature our more modest forms of Orchids and Ferns possess a special attraction. Orchids are in all ways a group of surpassing interest. This interest centres in the flowers, with their amazing range of form and colour, both of which features are connected with their remarkable structure in relation to cross-fertilization by insects. Though the British Orchid flowers are small in comparison with the gorgeous tropical forms, they nevertheless exhibit a variety of adaptation that may well hold the student's attention. In other directions, too, our Orchids invite study. From the point of view of geographical distribution, no British Natural Order offers a more varied field, nor problems of more profound importance in the study of plant-migration. Like the Heaths and Gentians sketched in my last article, the Orchids are a thoroughly *wild* group. Not a single member of the Order seeks the haunts of man. Towns and tilled ground know them not; only a few will flourish freely in cultivation, however we coax them. The meadows, heaths, woods and marshes are their stronghold; here, amid Meadowsweet and Heather, Gorse and Sedge, and in dark woods among beds of rich humus, they open their strange flowers, and disperse their curious powdery seed.

The British Orchids are all, like their foreign associates, herbaceous perennial plants; but while a large number of the exotic species are epiphytic in habit, perching on the damp branches of trees and climbers in steaming tropical forests, the British Orchids are all terrestrial. The majority live among the crowded herbage that peoples the meadows and copses. The root-system of most of these consists of a bundle of fleshy fibres. Each season one of the fibres produced swells into a tuber, which fills itself with food for next year's shoot as the previous year's tuber exhausts itself. The shoot which rises annually from the shortened root-stock produces a number of lanceolate or strap-shaped alternate leaves, and ends in a spike of flowers of various colour and form. A few, such as the Bird's-nest Orchis (*Neottia Nidus-avis*), which have their home in dark woods, are saprophytes. They draw the whole of the nourishment they require from decaying vegetable matter; green leaves being thus rendered unnecessary, are absent; and the plants are of dull hues of brown and yellow. One of our British Orchids, the Marsh Helleborine (*Epipactis palustris*), has an underground root-stock which creeps extensively—half a foot per year, or more—producing each season a leafy flowering-shoot, and a bunch of root-fibres for its nutrition; and the Creeping Lady's-tresses (*Goodyera repens*) has a similar creeping habit. The saprophytic species have all curious roots and root-stocks. In the Bird's-nest Orchis the root-stock is shortly creeping, surrounded by a dense mass of brown fleshy root-fibres, which bear only a very distant resemblance to a bird's nest. In the Leafless Epipogum (*E. aphyllum*), and the Coral-root (*Corallorrhiza innata*), two very rare species, the root-stock is composed of a branching fleshy mass, resembling coral. Three of the British Orchids are inhabitants of bogs—the very rare *Spiranthes æstivalis*, the Fen Orchis (*Liparis Loeselii*), now almost or quite extinct owing to the draining of the fens, and the tiny Bog Orchis (*Malaxis paludosa*), a greenish-yellow plant a few inches high, growing in cushions of Sphagnum. Both of the last-named species produce each year a bulb-like bud by the side of the old one; and *Malaxis* is in addition proliferous, bearing a bead-like fringe of tiny bulbils round the edges of its short leaves.

Let us next examine the structure of an Orchid flower—any of our common meadow species of *Orchis* or *Habenaria* will suffice. The ovary is inferior and drawn out, so that it looks like the stalk of the flower, which is in reality

Fig. 1. — Single flower of Sweet-scented Orchis (*Habenaria conopsea*). 1, Axis of the flower-spike; 2, bract which subtends each flower; 3, the twisted ovary; 4, the upper sepal; 5, 5, the lateral sepals or wings; 6, 6, the lateral petals; 7, the lower petal or labellum; 8, the spur formed by the backward prolongation of the labellum; 9, the two anther-lobes; 10, the stigmatic surface.

sessile. The calyx, consisting of three sepals, as in many Monocotyledons, is coloured and corolla-like. The corolla consists of three petals, also coloured, and alternating with the sepals. As the flower expands, the ovary twists through half a turn, thus inverting the flower, and making the lowest part the uppermost. Thus inverted, the flower exhibits a large upper sepal, which arches over the blossom, forming a kind of hood; the remaining two sepals, called the wings, spreading horizontally on either side. Of the three petals, two comparatively small ones join the upper sepals in providing a roof for the essential organs; the third (the *labellum*), much expanded and brilliantly coloured, spreads downward; it is continued backwards into a long hollow spur, in which honey is secreted. The ovary is prolonged forwards into the inner part of the roof of the flower, where it forms a fleshy projecting mass (the *column*), in which the essential organs are embedded. The single stamen—single in all British Orchids except the Lady's-slipper (*Cypripedium*)—consists of a two-lobed anther embedded in the column. Each lobe of the anther

* For the use of the figures which illustrate this article, the writer is indebted to Messrs. C. Griffin & Co., Limited. They are taken from his "Open-air Studies in Botany."

splits lengthwise, revealing a number of pollen-grains held together in a club-shaped mass by a number of delicate threads. Each of these pollen-masses is continued downwards in a delicate stalk which terminates in a sticky pad overhanging the entrance to the honey-tube. The pistil is represented by a sticky flat surface, corresponding to two stigmas, placed a little below the stamen; the third stigma being modified into a knob of varied shape (the *rostellum*), between the anther and the stigmatic surface. This remarkable flower-structure is especially adapted for cross-pollination by insects, self-pollination being practically impossible; and, furthermore, only a very few chosen insects can reach the honey, or fertilize the plant. We can imitate the visit of a bee, which is one of the favoured agents, by gently inserting into a newly-opened *Orchis* flower a sharpened lead pencil, and we will understand how this complicated mechanism works. The hypothetical bee's head, pushed into the entrance of the flower (as the insect hangs on the convenient landing-stage formed by the labellum), in order that its proboscis may reach the

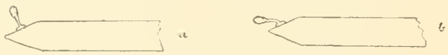


FIG. 2.—Pollen-mass of Orchis, withdrawn by insertion of a pencil into the flower. *a*, Position when withdrawn. *b*, Position after exposure to the air.

honey stored at the end of the long spur, comes in contact with the sticky knobs which terminate the pollen-masses. One or both attaches itself to our pencil, which draws it out of its sheath as we withdraw it. And now rapid and remarkable changes occur. In about half-a-minute the attaching cement sets hard and firmly fastens the mass to its newly-found support. At the same time, owing to the unequal contraction of the stem of the pollen-mass, caused by drying, its axis becomes bent, and it rapidly bends through a right-angle, so that the bundle of pollen no longer stands upright on the pencil, but points forward. What will happen when our hypothetical bee visits another flower, we can see. When the bee's head is inserted into the second flower, the pollen which it carries will, owing to the deflection of its stalk, come in contact, not with the corresponding anther, but with the sticky stigmatic surface which lies immediately below: and thus cross-fertilization is effected. Furthermore, only a little of the pollen will adhere to this stigma, and as the bee visits further flowers, the pollen will be widely spread among the various blossoms, the bundle attached to the bee's head becoming smaller and smaller till at length only the flexible stalk remains. The above description will apply to most of our commoner Orchids, though even among the British species a considerable range of form is found. In *Epipogum*, *Liparis*, and *Malaxis* the flower is not inverted, the labellum being uppermost: but in *Malaxis* this is caused, curiously enough, not by the ovary being untwisted, but by its being twisted twice as much as usual, the flower-bud making a complete revolution. Thus, in the curious *Epipogum* we find the coloured labellum forming the roof of the flower, the yellowish lanceolate sepals the landing-stage; the anther and stigmas are placed on the floor, instead of the roof of the tube, the pollen adhering to the under-side of the visiting insect. In the Bee Orchis (*Ophrys apifera*), again, the anther-lobes are not embedded, but dangle freely in front of the stigmatic surface, against which they are blown or pushed, this plant being apparently always self-fertilized, in spite of its elaborate structure and brilliant colour, which point to entomophilous habits. The Tway-blade (*Listera*) and Bird's-nest Orchis (*Neottia*) are, as regards their flowers, remarkable in possessing an exceedingly sensitive rostellum, which, on the lightest touch, instantly ejects a drop of gummy fluid, which sets hard in a few seconds, firmly securing the pollen-mass to the object—presumably the head of an insect—which caused the disturbance.

The British Orchids are over forty in number—forty-four according to the *London Catalogue*, which includes one or two which are often treated as varieties. *Orchis* is the largest genus, numbering twelve species; and with the allied genus *Habenaria*, constitutes the bulk of the Orchid flora of our meadows. These are all plants with roundish or palmated tubers, succulent stems and leaves, and spikes of purple, red, pink, greenish or white blossoms, many delicately fragrant. The Early Purple Orchis (*O. mascula*), and the Green-winged (*O. Morio*), the latter

FIG. 3.—Flower of Early Purple Orchis (*O. mascula*). 1, Side view; 2, front view. Natural size.

not found in Scotland, appear first, and brighten our spring pastures. Following them comes a rush of meadow Orchids in June—the Spotted (*O. maculata*), Broad-leaved (*O. latifolia* and *O. incarnata*), Pyramidal (*O. pyramidalis*) very rare in Scotland, Butterfly (*Habenaria chloroleuca*

FIG. 4.—Flower of Spotted Orchis (*O. maculata*). × 2.

FIG. 5.—Flower of Butterfly Orchis (*Habenaria chloroleuca*). Natural size.

and *H. bifolia*), Sweet-scented (*H. conopsea*), and the little Frog Orchis (*H. viridis*), appear in profusion, forming one of the most charming sections of our native wild flowers. The remaining species of these two genera are not so common. The dark little *Orchis ustulata* is frequent on limestone or chalk in England, but does not extend to Scotland or Ireland. The Lizard Orchis (*O. hircina*), a fine plant with a remarkable long curly labellum, is an exceedingly rare plant of the chalk. *O. purpurea*, also a comparatively large plant, is almost confined to Kent. *O. militaris* has a very limited range in Herts, Berks, Oxford and Bucks. *O. simia* seems to be confined to Oxford, Berks, and Kent. The last three are all chalk plants, and have been much confused. The rarer species of Habenaria are *H. albida*, a plant which loves pastures on the fringe of the mountains, and has a wide distribution, and the rare little *H. intacta*, or Close-flowered Orchis (=*Neotinea intacta*), growing on limestone pastures in the West of Ireland, and to which we shall refer again

later. Our meadows may also yield one or other species of the remarkable genus *Ophrys*, in which the mimicking of animal forms by the flowers is carried to a truly wonderful degree. The beautiful Bee Orchis is the most

FIG. 6.—Flowers of Bee Orchis (*Ophrys apifera*). Natural size.

frequent of these, with showy pink sepals, and velvety recurved labellum, looking marvellously like a bee's body. It ranges over England and the greater part of Ireland, and, like all the members of its genus, loves a limy soil. The Fly Orchis (*O muscifera*), which has a similar distribution, is a smaller plant, with dark red flowers which mimic the appearance of a fly—head, body, wings and legs complete. *O. Arachnites* and *O. aranifera*, the Early and Late Spider Orchis, are local English chalk plants. Allied to the foregoing are the Man Orchis (*Aceras anthropophora*), a little yellowish Orchid with a long lobed labellum with an outline resembling the human body, with its arms and legs; and the Musk Orchis (*Herminium Monorchis*), a small green plant widely spread over the East of England.

Epipactis and *Cephalanthera*, the Helleborines, are rather tall plants with leafy stems and lax spikes of flowers. In root, stem, and leaf they are less succulent than the genera we have been considering. In the structure of the flower they are simpler. The root-stocks are tufted or creeping, and devoid of tubers. They are chiefly plants of woods and rough ground. The best known is *Epipactis latifolia*, Broad-leaved Helleborine, with a stem a couple of feet high, clothed with broad pointed leaves, and terminating in a long spike of greenish flowers mottled with purple and brown. The Marsh Helleborine (*E. palustris*) is a shorter plant with fewer leaves and flowers; the flowers are very beautiful, being large and white, or tinged with pink, with a large lip contracted above, broadened and delicately fringed below. It inhabits wet ground, and has already been mentioned as creeping extensively. *E. atro-rubens* is a very local plant which haunts the bare limestone pavements of England and Ireland; its blossoms are dark red in colour. *Cephalanthera* includes three British species, all handsome tallish plants with lanceolate leaves. *C. grandiflora* and *C. ensifolia* have white blossoms composed of five almost equal segments and a short labellum tinged with yellow; the former has its headquarters in the south of England, the latter is widely but locally distributed in our islands. The Red Helleborine (*C. rubra*) is a very rare chalk plant, with purplish-red blossoms.

Spiranthes is an interesting genus, easily recognised by the spiral arrangement of the flowers. *S. autumnalis* (Autumnal Lady's-tresses) is a small plant flowering in August, and widely spread in dry pastures on a limy soil in England and Ireland. The flower-stem rises several inches from a little tuft of leaves, and bears a spike of small deliciously fragrant white blossoms, arranged in a single spiral row. The Summer Lady's-tresses (*S. æstivalis*) is a taller plant, with minute whitish blossoms arranged as in the last. It is an extremely rare bog plant, which has been found in Hants and Worcester. Finally we have *S. Romanzoffiana*, the most famous of all British Orchids, of which, till lately, the only known European station was in Co. Cork; it has lately been found in several spots in the north of Ireland, in the valley of the River Bann. It is larger than either of the preceding, with a spike of exquisitely fragrant greenish-white flowers arranged in three spiral rows. *Goodyera repens*, the Creeping Lady's-tresses, is almost the only British Orchid which has a northern distribution. It is frequent in the north of Scotland, coming as far south as Cumberland. It is an inhabitant of fir-woods, and its root-stock creeps extensively amid the decaying fir-needles which cover the ground. The slender flower-stem rises from a cluster of rather broad short leaves, and bears a *Spiranthes*-like lax twisted spike of small white flowers.

FIG. 7.—Autumnal Lady's-tresses (*Spiranthes autumnalis*). Two-thirds natural size.

Of *Listera*, or Tway-blade, we have two species. *L. ovata* is a common plant, growing with the familiar species of Orchis and Habenaria in meadows, etc. It is easily recognised by its nearly opposite pair of large egg-shaped leaves, and long narrow spike of small greenish-

FIG. 8.—Flower of Tway-blade (*Listera ovata*). 1, Side view; 2, front view. × 2.

yellow flowers. *L. cordata*, the Mountain Tway-blade, is a delicate tiny plant which has its home among the moss under deep Heather on mountains. Its leaves are heart-shaped, its blossoms extremely small. The root-system of *Listera* consists of a bundle of fleshy root-fibres surrounding a bud, and devoid of tubers.

The remaining genera of British Orchids, six in number, are represented by only one species each. Most of them have already been mentioned in one or other connection.

Of the three leafless saprophytic kinds, the Bird's-nest Orchis, *Neottia Nidus-avis*, is easily known by the pale brown colour of its stem and flower-spike, resembling the dead beech-leaves among which it loves to grow. It is a comparatively large plant, attaining a foot or more in height. In general appearance it is very like the parasitic Broom-rapes (*Orobanche*), but the flower has all the characteristic features of the Orchid. The Coral-root (*Corallorrhiza innata*) sends up from its curious branching root-stock a slender greenish stem devoid of leaves (though bearing a few sheaths) which terminates in a lax spike of small whitish flowers. This is a rare Scottish plant, growing in boggy woods. The third saprophyte, *Epipogum aphyllum*, is a pale yellow leafless plant with flowers variegated with pink. In Great Britain its inclusion in the flora rests on a single station discovered many years ago in Herefordshire, where it has not been seen since.

Of the three remaining Orchids, *Liparis Loeselii*, the Fen Orchis, now nearly extinct, has a pair of comparatively large basal leaves, and a spike of a few small whitish flowers. Next we have the tiny Bog Orchis (*Malaxis paludosa*) already referred to, a little fleshy yellowish plant, found in clumps of Sphagnum on bogs here and there throughout the British Islands. Lastly, a very different plant claims our attention—the beautiful Lady's-slipper, *Cypripedium Calceolus*. This plant differs materially in structure from all other British Orchids; it has two stamens instead of one, and the whole flower is constructed on a different model, the labellum being very large and pouch-shaped. In our only British species the large and beautiful flower is maroon, with a yellow labellum. It is a very rare North of England plant, now probably extinct.

Reviewing generally the distribution of our Orchids, we find that they are on the whole a lowland lime-loving group. Only a little over a dozen species out of over forty have a thoroughly wide distribution; most of the others have their headquarters in the south and east of England, where the chalk prevails, whence some, such as the Pyramidal Orchis, Bee Orchis, and Autumnal Lady's-tresses, spread outwards for a considerable distance; others, like the Red Helleborine and *Orchis simia* and *militaris*, being confined to one or two stations within that area. A few (*Liparis*, *Spiranthes æstivalis*, and *Malaxis*) are bog plants, all but the last being of very restricted English range. *Habenaria albida* and *Listera cordata* haunt the uplands. Two species, the Creeping Lady's-tresses and the Coral-root, are northern, and with us confined to Scotland. The lovely Lady's-slipper has, or had, its home in the North of England.

Lastly, we have two particularly interesting outlying species, found in the British area in Ireland alone—*Habenaria intacta* and *Spiranthes Romanzoffiana*. These at once arrest the attention of the student of geographical botany as representing the two extremes of our flora—the furthest limits from which the elements which compose our present vegetation have been drawn. *H. intacta* is a characteristic Mediterranean species, inhabiting Spain and Portugal, southern France, Italy, Dalmatia, and Greece. A wide stretch of sea and land separates it in its Irish home from its next present habitat. It is probably a very early inhabitant of Ireland, which in old days crept northward along a former European shore-line which has now long disappeared below the waves. Here, on the warm limestones of the almost frostless west of Ireland, it still survives in quantity. The other Irish Orchid, *Spiranthes Romanzoffiana*, has a very different origin, but a similar tale to tell. This is a sub-Arctic plant, with its headquarters in Canada and the northern United States. It has crept across Behring Sea into Kamtschatka, but elsewhere in the Old World it is known only in Ireland. To account for its presence here, we must assume that land formerly occupied part of the area now covered by the North Atlantic Ocean. Perhaps by way of Greenland and Iceland the plant may have migrated eastward; possibly the lonely peak of Rockall, or the Porcupine Bank, represents the wreck of its former home. But here, cut off by thousands of miles of sea from its nearest settlement, it grows still, a living monument of the changes that earth has seen even since our present flora began to colonize the land.

CONSIDERATIONS ON THE PLANET MARS.

By E. M. ANTONIADI, F.R.A.S.

It is now more than a quarter of a century since Schiaparelli called attention to the "canal" system of Mars, and, during this time, thought has been active in framing theories to account for the new facts revealed by observation. So long as the term "canal" was agnostically applied to streaks which united to one another the so-called "seas" of the planet, there could be scarcely any improvement on its choice, and no objection to its use. But when the Milan observer spoke of the "robust dikes" and "inundations" of these "canals," the care of opening whose locks would have been committed to the Martian Secretary of State for Agriculture himself, a distinct shade was cast on the seriousness of the term in question.

Two years had not elapsed after the discovery of the "canals" before the late Mr. Green urged the objection that some of them were nothing else than the edges of faint half-tones; and that, in such markings, it was difficult to recognise the earthly attributes of water channels. But this far-reaching remark of the gifted English observer was soon cast into oblivion before the apparently weightier evidence of Schiaparelli's observations, which, for many years, seemed to carry everything before them. It was gradually realised, however, that to assume the full objective reality of the Milan results implied such a startling state of things on our ruddy neighbour, that it was no longer safe to follow Schiaparelli's *interpretations* to the letter. But no one ever thought of challenging the veracity of the various telescopic *impressions* disclosed by the laborious watches of the great Italian astronomer. Slowly and patiently those results have been exhaustively confirmed by the ablest followers of Schiaparelli, and are now permanently acquired to science.

We are indebted to the abnormal peculiarities of the "canals" for that seasonable reaction. Their sudden shifts of position, leaps, disappearances, reappearances, intensifications and duplications, marked out the "canals" as rather the inconstant vagaries of physiological phenomena than as the permanent features of a cooling world. All Martian energy must necessarily have its source in the sun, since the presence of polar snow-caps shows us the surface of the planet to derive so small a quantity of heat from the interior as never to enable it to attain, unassisted, the freezing point of water, or perhaps even of carbon dioxide. The elegant cosmogonical speculations as to the youth of Mars are thus completely outweighed by this more credible observational testimony.

The question of the objectivity, or of the subjectivity of the "canals" has frequently been examined, and often decided one way or the other. A careless observer would, in fact, deem it more reasonable to consider the "canals" either as wholly imaginary, or as wholly real, than as a mixture of both reality and illusion. He could speciously argue that there must be one single cause for the canal impression; and that, by tracing the latter to a variety of sources, our reasoning becomes unphilosophical, and betrays

our inability to deal with this obscure question. But, as ably pointed out by Mr. Maunder in the exposition in this number of Knowledge of his most valuable experiments, we have now reached a stage where we are certain of the existence of some dusky streaks, and justly suspicious of the reality of others. The "canal" named Cerberus, for instance, is often as dark and definite as a "sea"; its objectivity is thus above question, unless, indeed, we come to doubt the very existence of large dusky areas on Mars. Several other "canals"—say one-third of the whole number—have also more or less strong claims to reality; although some of them are only the boundaries of the half-tones to which Mr. Green has called attention, while others, in accordance with Mr. Maunder's theory, are an integration of visible minute, or still smaller, and invisible, details. The philosophical importance of Mr. Maunder's experiments lies in the demonstration that, in order to appear furrowed with "canals," the Martian deserts require only an irregular distribution of any kind of minute grey markings. We need, therefore, no longer believe that "a Martian would be fifty-fold more efficient than man, whether in digging canals, or in other bodily occupation";* and thus, for the suspicious achievements of the hardy canal digger, modern science has fitly substituted the more rational interpretation of physiological principles.

During the last opposition of Mars, in the early spring of 1903, the writer was enabled to confirm part of Mr. Maunder's theory for two "canals," the Oxus and the Casius, both of which were seen composed of a congeries of small dark spots, at the limit of visibility (*see* the annexed Plate, drawings of April 6th, $\omega = 341°$, and April 11th, $\omega = 260°$). These observations were made with an $8\frac{1}{2}$-inch reflector by Calver, magnifying 292 and 408 diameters, the excellence of whose mirror rendered possible an abnormally sharp view of the "canal" Oxus. Instead of uniting, as usual, Margaritifer Sinus to Arethusa Lacus,† the Oxus ran, as in 1886, into Ismenius Lacus, being very narrow and black towards the south, then swelling out into a lake-like patch, and finally fading off into Ismenius Lacus. Equally objective, though less sharp, were the so-called "canals" Cerberus, Cyclops, Hades, Eurotas, Nilokeras, Nilosyrtis, Pierius, and Protonilus; while a weird black hook, curving out of Ismenius Lacus in a southerly direction, also gave an overwhelming impression of reality.

Having thus admitted the partial objectivity of the Schiaparellian "canals," though carefully avoiding to consider them as artificial watercourses, we must now give our reasons for refusing to accept them in their entirety. Doubt arises here from the fact that the Milan observer has seen subjective "canals" on Mercury also; and that, as shown by Mr. Lowell's planetary observations, and by Mr. B. W. Lane's invaluable experiments,‡ the "canaliform illusion" is a normal physiological phenomenon. If, therefore, non-existent "canals," as harsh as the markings on the moon, affect the discs of other planets, they are also certain to attack the appearance of Mars; and there must be a limit beyond which the phenomena of the real Martian "canals" are continued, or imitated, by the illusions of prolonged eye-strain, if not of fancy.

If we inquire into the relevancy of Mr. Green's interpretation for some "canals," we shall find that it accounts for one-half of the linear markings. Its principle may be illustrated by a representative example. While in 1883-1884 Schiaparelli was seeing the region called Utopia as a yellow triangular area, limited by black "canals" (Fig. 1), Mr. E. B. Knobel, F.R.A.S., one of our ablest authorities on the planet, was seeing the same region intensely shaded (Fig. 2).

We are naturally curious to know which of these two

Fig. 1.

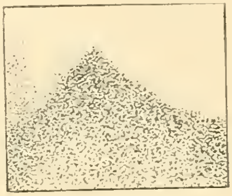


Fig. 2.

The Region Utopia on Mars, as seen in 1883–1884 by Prof. Schiaparelli and Mr. Knobel.

Illustrating the Instrumentality of Contrast in reducing a Dusky Shading into a Canal-girt Bright Area.

appearances expresses more truthfully the actual configuration of this part of the Martian surface. A little consideration will render it evident that, since the dark area seen by Mr. Knobel is not resolved into separate dusky markings by Schiaparelli, the Englishman's representation is more trustworthy than the Italian's—a result which implies that the eye of Schiaparelli is affected by a strong personal equation, or a peculiar physiological bias, which strains it to decompose dark spots into more or less bright polygons, limited by black "canals."

But contrast does not confine its action to the intensification of the boundaries of faint half-tones. Enjoying a much greater generality, it affects the appearance of all definite markings of the surface. A mere glance thrown

Fig. 3.—The Syrtis Major, as seen by Schiaparelli on 1888, June 4th.*

Illustrating the Instrumentality of Contrast in breaking up the Intensity of a very Dark Area into a Pale Shading limited by Black "Canals."

on Fig. 3 will suffice to corroborate this assertion. Here we have to deal with an observation, by Schiaparelli, of

* Lowell, *Mars*, p. 205.

† For the identification of the markings see the Chart of Mars in Knowledge for November, 1902, p. 252.

‡ Knowledge for November, 1902, pp. 250-251.

* *Memorie Sesta*, Pl. IV., Fig. 10.

the Hour-Glass Sea—always the most conspicuous, and often the darkest, area on Mars—in which the heavy shading of that great "sea" is shown reduced to a pale triangle, bound by "very black" lines.* Were this an isolated case it might have been argued, with some glimmer of probability, that the limiting "canals" were real objects. But the appearance shown on Fig. 3 is only a clearer representation than usual of a constantly recurring phenomenon, since the darkening of the Martian "seas" near their "shores" has been invariably one of the leading features of Schiaparelli's delineations.

Such a systematic intensification of the margins of the dark spots, implying as it does the incongruity, even if it be the only one of nomenclature, that the seas of Mars are themselves bounded by canals, cannot correspond at all to objective markings of the surface. That the intensity of the grey spots is far from being uniform no one will deny; but to maintain that real differences of albedo so manage their distribution as to imitate exactly the phenomena of contrast, is to deny the weight of philosophical probabilities which have all the force of practical certainties.

These conclusions may now be checked by deduction. If due to contrast, the marginal "canal" ought to be sharply bounded on the outside, but to shade off more gradually into the darker expanse beyond; and it is noteworthy that this corollary is in exact agreement with Signor Schiaparelli's experience, since, speaking of the "canal" limiting Syrtis Major on the following side, he says that "along Aeria, it was better defined to the right than to the left,"† or better on the bright side than on the dark one.

The apparent intensification of all indentations of the Martian "coasts" is another inference from our proposition, and is equally in harmony with experience. Let M in the annexed Fig. 4 be a grey area, whose border, R S, is exalted by contrast into the familiar black "canal"

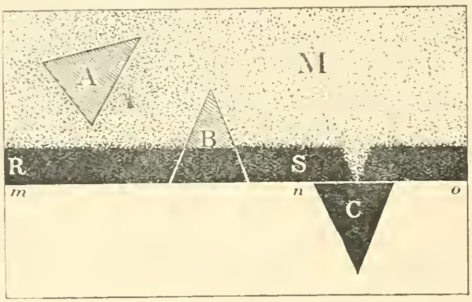


FIG. 4.—Illustrating the Effect of Contrast in enhancing the Darkness of the Indentations of the Martian Coasts.

appearance; and let us now consider the influence of position on the apparent darkness of a dusky triangle, having the same albedo as the dark spot M. As long as our triangle remains outside the illusive "canal" snare, as at A, it is, of course, indistinguishable from the general duskiness; but it its base coincide with the limits *m n* of the grey spot, as in B, part of it will be immersed in the intensification; and if again the triangle be turned by 180°, the line *m n o*, playing the part of a hinge, as at C, a larger proportion of its perimeter is exposed to contrast, and it will be cast at once into blackness. But what, may we ask, will be the observer's impression on the darkness of the indentation? Prompted by a zeal for detecting new features, and scrupulously recording every one of his impressions, he will be a little biased in favour of tracing to an objective source all the facts revealed by his exhausting scrutiny. He will not hesitate to consider the intensified estuary as corresponding to a real difference of tint; and areography will be enriched forthwith by the discovery of a brand new oasis.

Our apparent knowledge of Mars thus always exceeds our real knowledge, and this conclusion may be confirmed by further considerations. When a disc representing the appearance of the planet, without canals, is long examined in ordinary sunlight, the law of contrast causes the borders of the continents to appear fringed with a filiform whiteness, such as has been experienced by all Martian observers. In addition to this, however, the eye will detect a duller and much broader intensification of the "coasts," which, striking its roots in contrast also, runs parallel to, and at a distance from, the outline of the "Maria." The generally uniform albedo of the ruddy deserts is thus also shown to appear affected by physiological vagaries; and the unguarded observer, who cherishes the objectivity of his discoveries, will either lay stress on the brightness of the bordering lands, or insist on the duskiness of the adjoining wilderness. But the important point here is that the limit of the two tints is often raised to a canaliform darkness—a conclusion which justifies in some measure* Mr. Lane's theory that "the mere shape of the oceans of Mars is sufficient to give rise to the appearance of the complicated system discovered by Schiaparelli."†

"Canals" are thus artificially developed which happen to lie in the same positions as some of those discovered at Milan. If the "coast" is straight (Aeria), the concomitant "canal" is also straight (Phison); if the "coast" is curved (Libya), the "canal" is also curved (Nepenthes); and if the dark spot be oval (Solis Lacus), the bordering "canal" (Agathodæmon-Phasis) will run concentrically with the outline of its objective generator. Whether this constitutes a complete explanation of the "canals" in question or not it is scarcely wise to decide; but it seemed interesting to call attention to such a remarkable agreement between physiological necessities and the facts of experience.

It now remains to consider the effect of contrast on a dusky streak, such as the cigar-shaped Mare Cimmerium, whose broadest end evaporates into half-tones. Fixity of gaze should enhance its edges and brighten its interior into a cometary impression, exactly as seen by Schiaparelli.‡ Then again the narrow Sinus Sabæus should also present itself with a lighter interior, and the fleeting visibility of Xisuthri Regio is a literal corroboration of this statement. Scheria Insula in 1882, and Sirenia in 1892, furnish us with kindred examples. But this is a phenomenon which, according to Schiaparelli himself, is intimately related to gemination; and it is obvious that, by the forced enhancement of their edges, all lakes§ and all broad objective streaks or "canals" will appear duplicated. And thus, by a mere enquiry into the laws of contrast, the

* "Lince . . . . molto nere." *Memoria Sesta*, p. 74.

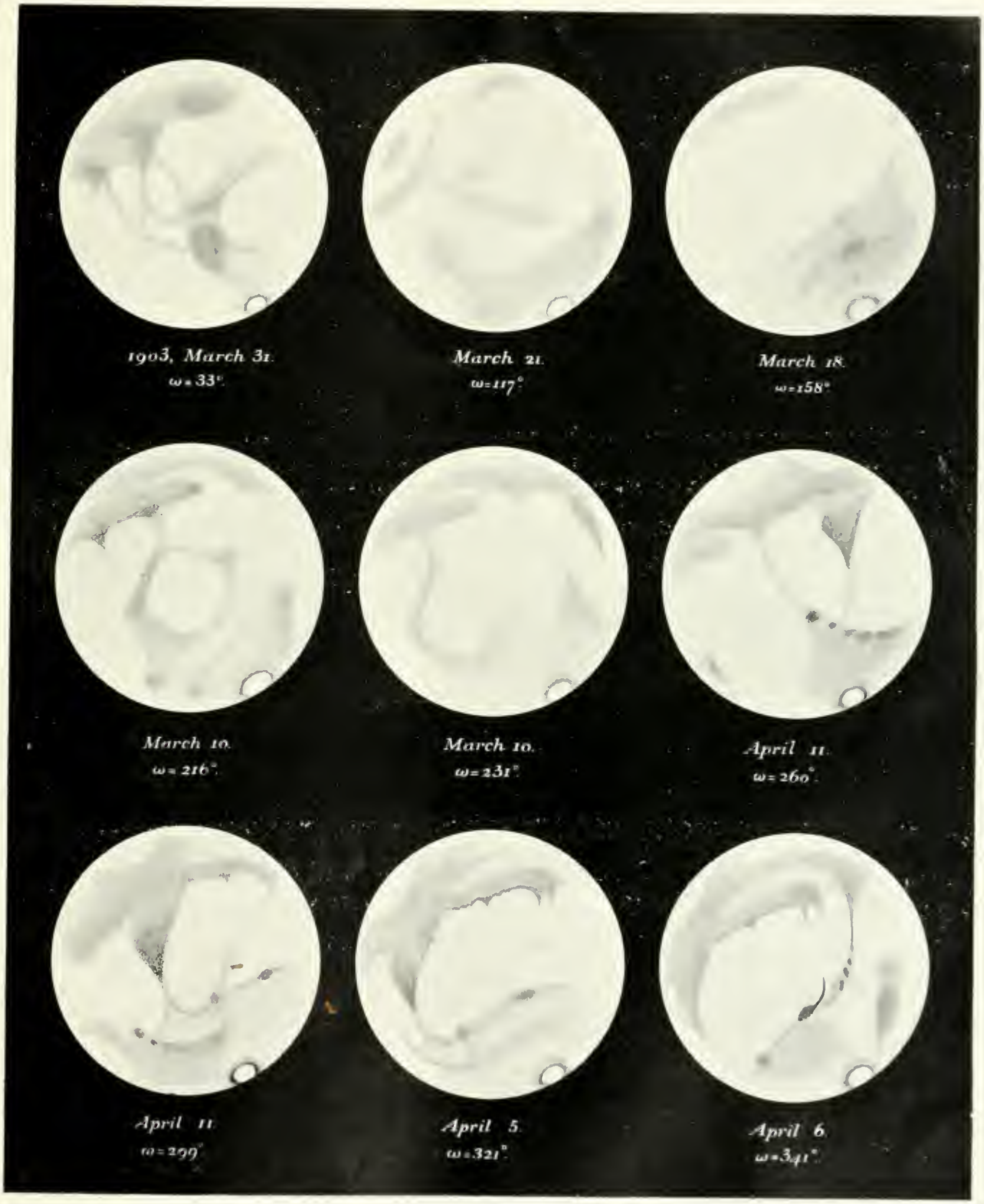
† *Ibid.*, p. 75.

* Of course, contrast may account for such "canals" running parallel to the "coasts" a long way inwards; but it is incompetent to explain "canals" forming an angle with them. Hence Mr. Lane's theory is only partly confirmed by contrast.

† KNOWLEDGE for November, 1902, p. 250.

‡ Cimmeria Insula, in 1882.

§ The long examination of a small dusky eclipse tends to double it into round spots.



TELESCOPIC VIEWS OF THE PLANET MARS IN THE SPRING OF 1903.

Reproduced from Drawings by E. M. ANTONIADI.

appearance of Fig. 5, which summarizes our solid knowledge of the Martian surface, may be conjured, by fixity of gaze, into Fig. 6, or into a subjective breakdown of the

Fig. 5.—An Elementary View of our Real Knowledge of Mars.

Fig. 6.—An Elementary View of our Apparent Knowledge of Mars.

Illustrating the Action of Contrast in generating "Canaliform" Sensations, as well as in decomposing the Tints of the Shadings, and thus probably paving the way for the Duplication of the Markings.

colour of all spots, as well as into a system of single-and-double canals. It would perhaps be imprudent to affirm at present that in contrast we have the sole and sufficient explanation of gemination. But what is at any rate certain is that it offers a very simple interpretation of at least a great many cases of doubling; and that the writer fails to see any fatal objection to it. Nor can we reasonably overlook the fact that whenever gemination has been playing havoc with the "canals" and "lakes," the phenomena of contrast have also been plainly evident in the appearances presented by the planet.

We are insensibly being brought to a standstill, and future enquiry on Mars must rather direct its efforts to the differentiation between subjective and objective in the known details, than in the discovery of novel complications and further developments in the "canal" system. By a singular fatality, the observations made with ordinary appliances in the smoky and troubled atmospheres of English towns have always equalled, and often excelled, those obtained with giant telescopes in the stillness of elevated deserts. Definition does not, therefore, improve in a direct ratio with an increase of height above the sea level, whilst an excess of instrumental power has itself proved powerless to reveal new features on a medal lying at the bottom of a shallow stream.

THE CANALS OF MARS.

By E. Walter Maunder, F.R.A.S.

Just a year ago a very interesting paper under the above heading by Mr. B. W. Lane appeared in Knowledge; in which he described a series of experiments tending to show that "the mere shape of the oceans of Mars is sufficient to give rise to the appearance of the complicated system discovered by Schiaparelli."* Mr. Lane's paper led to Mr. J. E. Evans, headmaster of the Royal Hospital School, Greenwich, and myself, undertaking together a series of experiments with boys in that school, from which some interesting results have been obtained. At the time when Mr. Lane's paper was published only a small proportion of these experiments had been carried out, and I was not therefore able to speak as definitely as I now can as to the conclusions to be drawn from them. These experiments were supplemented by others, made chiefly by Mrs. Maunder and myself, on the impressions produced by lines and dots when near the limit of vision, which further illustrate the subject.

The experiments at the Royal Hospital School were made in the following manner:—A class of about twenty boys, from twelve to fourteen years of age, were seated in four or five rows at different distances from a carefully-lighted diagram, which they were told to copy. The diagram was reproduced from some published drawing of Mars, but in nearly every experiment the canals were omitted. For the most part any boy was used in only one experiment; but a few were set to draw the same diagram twice, the second time at a different distance from the first. The diagram was generally about six inches in diameter, and the distances of the boys from the diagram ranged from fifteen to forty feet, except in two experiments where the range extended up to sixty feet.

One set of experiments is illustrated in the accompanying diagrams. Taking as basis Plate VIII. in Mr. Lowell's "*Mars*," showing the Mare Sirenum and the region north of it, we arranged three variations on it, on a scale of about six inches, and submitted them to three different sets of boys. The first variant (Fig. 1), showed chiefly the "oases"; the second (Fig. 3), only the "canals"; the third (Fig. 5), neither "oases" nor "canals," but irregular lines. The results of an experiment with the region of the Syrtis Major as subject are illustrated in the *Monthly Notices* of the Royal Astronomical Society, for June, 1903, Plates 18 and 19.

The general result was striking. In several of these experiments nearly all the boys drew "canals" on their copies, though there were none on the original from which they were copying. And these "canals" were not placed at random; they were just in the very places where canals are seen in the charts of Schiaparelli and Lowell. The boys agreed on the whole rather better in reproducing the position and direction of canals like Phison, Hiddekel, Euphrates, and Arnon, which were not on the original before them, than in reproducing the position and outlines of large and prominent markings like the Syrtis Major and Sinus Sabæus, which were very distinctly on the original.

But in no single case, out of considerably more than two hundred drawings, did we find a "canal" drawn, which seemed to owe its origin entirely to the shape of the neighbouring "oceans," or dark markings. Whenever the bright regions, the "continents," in the diagram, were left absolutely free from detail of any kind, then the copyists all, without exception, left it free also. We had not a single instance which could be taken as confirming Mr. Lane's result; at least in the form in which he has expressed it.

This result must be taken as negative only; we have no reason to assert that our experiments have disproved Mr. Lane's, only that they have not confirmed them. And an explanation of this difference in our results can be readily suggested. Mr. Evans and myself felt that the whole value of our experiments rested in the boys being left absolutely free from any suggestion, direct or indirect, that would lead them to suspect that there was something peculiar in the diagram which we wished them to see. We could not, therefore, press them to keep on staring at their model after they thought they had copied all there was to see. They did not strain their eyesight therefore, and so did not receive any of the impressions which strained eyesight

* Knowledge, 1902, November, p. 250.

might have occasioned. So far, therefore, as these experiments of ours go, we are not able to pronounce upon Mr. Lane's, either for or against.

Whence then did the "canals" come which were drawn by the boys of the Hospital School?

One cause was the prolongation of dark indentations invading the brighter regions. The Gehon and Hiddekel, for example, on the boys' drawings were clearly partly due to the two arms of Dawes' Forked Bay. This was my first suggestion as to the probable true nature of Schiaparelli's discovery, a suggestion made as long ago as 1882. But so far as our experiments go I do not think that many of the canals can be explained in this way. The Forked Bay and the two lakes Ismenius Lacus and Siloe Fons would be enough to some of our boys to show them Hiddekel and Gehon, but not to the majority.

A more fruitful source of the "canals" was the introduction of regions slightly darker or slightly brighter than their surroundings. Meroe Island figured as an example in the first category, Elysium as one in the second, in two different experiments. And no one could wish for straighter and sharper "canals" than were drawn by a good proportion of the boys to express these regions. A few put in shading, fewer still put in shading and drew also a dark canal as its boundary. There can, I think, be no reasonable doubt that Mr. Green, when in 1879 he suggested that the borders of faint shadings might have given rise to some of the canals, pointed out a cause not only equal to producing such an effect, but one that does so in reality.

Another cause which proved decidedly effective was the tendency of the eye to join together two small spots, where these were not too small to be separately seen, by a wholly subjective line. But the cause which was the most effective within the limits of our experiments with the Hospital School boys was the way in which the eye summed up together minute irregular markings, each too small to be separately perceived as straight streaks. An examination of the drawings with reference to the placing of the boys rendered this very evident. At fifteen or seventeen feet the boys were near enough to detect some, if not all, of the minuter details as separate entities, and hence drew few canals. At thirty-five or thirty-eight feet these details were for the most part too small to produce any effect, even in the gross, and therefore the boys here also drew few if any canals. But between these two extremes nearly every boy drew canals. Halfway between them every boy without exception saw "canals." For here, whilst the details were each one separately invisible, they were yet capable of creating in the sum a distinct impression.

And, seen at this distance, it was very striking to see how the eye, as it were "took the average" of all irregularities. Two irregular wavy lines drawn so as to cross each other, took form as a beautiful "oasis" with four straight canals radiating from it. Lines as meandering as the Thames or Trent with their tributaries on a map of England, straightened out as rigidly as the Phison or Euphrates on Lowell's chart. If Mr. Lane's effects were never secured with an entirely blank "continent," it was astonishing to see how effectively three or four dots, absolutely invisible at the distances occupied, would suffice to make those effects plain. Nor was it at all necessary that the dots should be put in a straight line where the canal ought to run. They might wander from it a good deal on either side, if only the mean line between them ran in the right direction.

It may be objected that very little has been gained if we recognise that the canals are either the edges of half-tone districts, or the summation of very minute details. The general distribution of the true markings on the planet must approximate to that shown on the charts of Schiaparelli and Lowell, and the details if not straight

Fig. 1.—Original. "Oases" only.

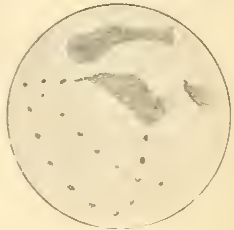


Fig. 2.—Copy of Fig. 1 at distance 23 feet.

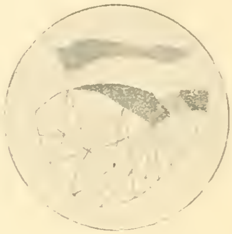


Fig. 3.—Original. "Canals" only.

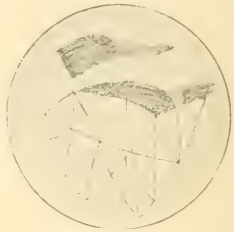


Fig. 4.—Copy of Fig. 3 at distance 22 feet.

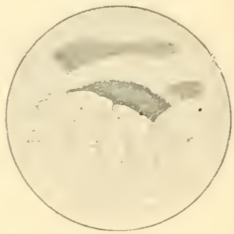


Fig. 5.—Original. Irregular lines.

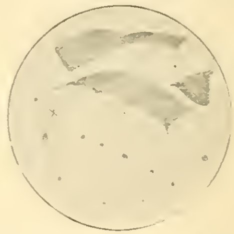


Fig. 6.—Copy of Fig. 5 at distance 33 feet.

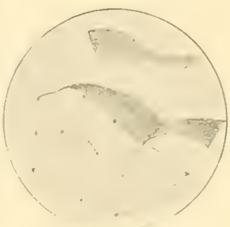


Fig. 7.—Copy of Fig. 5 at distance 24 feet.

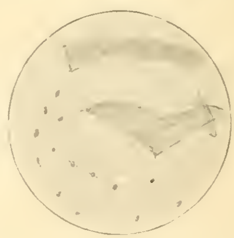


Fig. 8.—Copy of Fig. 1 at distance 28 feet.

The Region of the Mare Sirenum (with variations).

lines in their ultimate conceivable resolution are at least straight lines to the eye.

But the gain is really great. For so long as we conceive of that elaborate reticulation as being a true feature of the actual surface of the planet, we can hardly escape from Mr. Lowell's induction. Lines so straight, so formal, so

uniform in width, so regular in their intersections, so symmetrical, with dark spots so inevitably marking their intersections, must be accounted, as he accounts them, artificial; the handiwork of intelligent beings. But if actual details of perfectly irregular and unsymmetrical character, details having no sign of artificiality about them, can present exactly the appearance, and make just the impression which the network of the canal system does, the argument for the existence of inhabitants on Mars has vanished. We are freed, too, from the necessity of considering such bizarre theories as would make out the planet to have been scored into its present form by grazing meteorites, or to have assumed it through crystallization. To have been set free from the grotesque in observation is to have been freed also from the grotesque in speculation.

This service I think the drawings of the Hospital School boys have effectually rendered to us. They have shown that perfectly unbiased observers will see and draw the Schiaparellian canals when the actual markings presented to them are as little regular and artificial as any which our own earth might present to an outside spectator.

I do not think we need claim more for these experiments than this; a complete explanation of the canal system would probably involve other factors than those indicated above. Thus a most able letter by M. Antoniadi, which appeared in the *English Mechanic* for July 31st, 1903, sums up the canal-impression under five heads:—

"(*a*) Entirely physiological markings, like those seen by Mr. Lowell on other planets, by myself on Mars, and by Mr. Lane on his artificial discs.

"(*b*) Subjective lines, generated by the topographical details.

"(*c*) Edges of physiological half-tones, begotten by contrast.

"(*d*) Edges of objective half-tones, arising from the same reason. And

"(*e*) Incontestably real canals, which, were we to see Mars better, would resolve themselves into groups of knotted or unevenly shaded areas."

This classification cannot be much bettered with our present knowledge. I should myself give the first place to *b* as the most fruitful source of canals, and the next to *d*, these two classes being those with which our Greenwich experiments were concerned. The two physiological classes, *a* and *c*, were not included in our work. But I am inclined to think that they are intimately combined with the others in producing the canal system as we know it; and that its geometrical appearance is largely due to them. In the last class *e*, I should myself prefer to withhold the name "canal" from features which, like Nasmyth Inlet and Huggins Inlet, were well known long before the canal system as such had its commencement. I well remember that my first disposition to be sceptical of Schiaparelli's discoveries arose from the fact that he drew so many canals which I could not see at all as being equally distinct with Nasmyth Inlet which I had seen conspicuously. That may have been a bit of personal bias, but I think it is clear that whilst the canal system as a whole must be considered as subjective only, some markings which have been included in it have been too thoroughly well defined to be anything but real. At the present moment the most interesting feature with regard to the entire discussion is the tendency of the ablest and most favourably circumstanced observers to see the chief canals no longer as straight uniform lines, but as close sequences of spots, as if an approach had been made to their complete resolution. It is now a quarter of a century since the canals as such were first introduced to us. It may well be that the next quarter of a century may see such an advance that ere its close we may have detected the actual component details of what we now consider as straight lines, and that therefore the canals—as such—may have entirely disappeared

MODERN COSMOGONIES.

By Agnes M. Clerke.

V.—THE FISSION OF ROTATING GLOBES.

Few people need to be told that a rotating fluid mass is shaped very much like an orange. It assumes the form of a compressed sphere. And the reason for its compression is obvious. It is that the power of gravity, being partially neutralised by the centrifugal tendency due to axial speed, gains progressively from the poles, where that speed has a zero value, to the equator, where it attains a maximum. Here, then, the materials of the rotating body are virtually lighter than elsewhere, and consequently retreat furthest from the centre. The "figure of equilibrium" thus constituted is a spheroid, a body with two unequal axes. In other words, its meridional contour—that passing through the poles—is an ellipse; while its equator is circular.

Now we know familiarly, not only that a spinning sphere becomes a spheroid, but that the spheroid grows more oblate the faster it spins. The flattened disc of Jupiter, for instance, compared with the round face of Mars, at once suggests a disparity in the rate of gyration. But there must be a limit to the advance of bulging, or the spheroid, accelerated *ad infinitum*, would at last cease to exist in three dimensions! Clearly this unthinkable outcome must be anticipated; at some given point the process of deformation must be interrupted. A breach of continuity intervenes; the train is shunted on to a branch line. Nor is it difficult to divine, in a general way, how this comes to pass. Equilibrium, beyond doubt, breaks down when rotation attains a certain critical velocity, varying according to circumstances, and the spheroid either alters fundamentally in shape, or goes to pieces.

So much plain common sense teaches; yet the precise determination of the course of events is one of the most arduous tasks ever grappled with by mathematicians. M. Poincaré essayed it in 1885*; it was independently undertaken a little later by Professor Darwin†; and the subject has now been prosecuted for eighteen years, chiefly by these two eminent men, with a highly interesting alternation of achievement, one picking up the thread dropped by the other, and each in turn penetrating somewhat further into the labyrinth. The results, nevertheless, are still to some extent inconclusive; they indicate, rather than indite, the genetic history of systems. A strong light is, indeed, thrown upon it; but in following its guidance, the limitations of the enquiry have to be borne in mind. The chief of these are, first, that the assumed spheroid is liquid; secondly, that it is homogeneous. Neither of these conditions, however, is really prevalent in nature, so that inferences based upon them can only be accepted under reserve. They were adopted, not by choice, but through the necessities of the case. There was no possibility of dealing mathematically with bodies in any other than the liquid state. The equilibrium of gaseous globes defies treatment, except under arbitrary restrictions.‡ Nor is it possible to cope with the intricacies of calculation introduced by variations of interior density. Cosmical masses, as they actually exist, are nevertheless strongly heterogeneous, so that, at the utmost, only an approximation to the genuine course of their evolution can be arrived at by the most skilful analysis. Yet even an approximate

* "Acta Mathematica," Vol. VII., Stockholm, 1885.

† *Proc. Royal Society*, Vols. XLII., LXXI.; *Phil. Trans.*, Vols CXCVIII., CXCIX., Series A.

‡ J. H. Jeans, *Phil. Trans.*, Vol. CXCIX., A., p. 1.

solution of such a problem is of profound interest. We can here only attempt briefly to specify its nature.

The overthrow of equilibrium in a rotating liquid spheroid has, at any rate, been satisfactorily tracked. When its gyration quickens to a disruptive pitch, it acquires three unequal axes instead of two. The equator becomes elliptical like the meridians. A "Jacobian ellipsoid" is constituted. This new form seems to have had, in growing systems, a long spell of stability; only its major axis became more and more protracted as cooling progressed, and with cooling, contraction, and with contraction, the increase of axial velocity. Then at last a crisis supervened; there was a collapse of equilibrium, and its re-establishment involved the sacrifice of the last vestige of symmetry. An "Apioid" or pear-shaped body replaced the antecedent ellipsoid; and its apparent incipient duality suggested to M. Poincaré that the furrow unequally dividing it might have deepened, with still accelerated gyration, into a cleft, splitting the primitively single mass into a planet and satellite. But this eventuality, he was careful to note, had no direct bearing on Laplace's hypothesis, which dealt with a nebula condensed towards the centre, while the fissured apioid was liquid and homogeneous.*

Professor Darwin followed out the conditions of this remarkable pear-shaped body to a closer degree of approximation than its original investigator had done, and succeeded in virtually demonstrating its stability. His analysis, however, tended to smooth away the characteristic peculiarities of its shape, and, so far, to diminish the probability of its ultimate disruption. Mr. Jeans, on the other hand, from an elaborate study of a series of cigar-shaped figures which in theory follow a parallel course of development to that pursued by ellipsoids, derived, by strict mathematical reasoning, the actual separation of a satellite from one end of a parent-cylinder. The representative figures reminded Professor Darwin "of some such phenomenon as the protrusion of a filament of protoplasm from a mass of living matter." "In this almost life-like process," he saw "a counterpart to at least one form of the birth of double stars, planets, and satellites."†

But the resemblance, when examined dispassionately, seems shadowy and evasive; nor can we be sure that it extends to the case of double stars. Here, indeed, an entirely different set of conditions comes into play from that postulated by Poincaré and Darwin, since stars are certainly not liquid bodies. They are most likely gaseous to the core; though the indefinite diffusiveness incident to gaseity is restricted by their condensed photospheric surfaces. This circumstance intimates the possibility that the results arrived at for liquid globes by mathematical analysis may, with qualifications, be extended to stars; but the necessary qualifications, unfortunately, are vague and large; for too little is known regarding the physical condition of stellar spheres to warrant assumptions that might provide a secure basis for research. The evolution of binary stars can then only be treated of inferentially, not rigorously; and we must, at the outset, discard the idea that it is illustrated by the phenomena of double nebulæ. Many such objects, thought to supply clinching visual arguments for the actual effectiveness of slow cosmic fission, proved, on the application to them of the late Prof. Keeler's searching photographic methods, to be knots on spiral formations. Their mutual relations are then entirely different from what had been supposed by telescopic observers; they are, in fact, still structurally connected, and the mode of their origin, however inviting to conjecture, scarcely comes within the scope of exact enquiry. Their future destiny is no more accessible to it than their past history; and only by a daring flight of imagination can we see in spiral nebulæ the prototypes of double stars.

* "Figures d'Équilibre d'une Masse Fluide," p. 172.

† *Proc. Roy. Society*, Vol. LXXI., p. 183.

Questions as to the mode of genesis of these latter systems have, in recent years, acquired extraordinary interest. Conclusive answers cannot, indeed, at present be given to them, because the terms in which they are couched lack definiteness owing to our lack of knowledge; but probable answers may legitimately supply their place, at least *ad interim*, especially when their probability is heightened almost to certainty by the accumulation of circumstantial evidence.

Observations and investigations of stellar eclipses have created a new department of astrophysics, and have vastly widened the domain of cosmogony. For they have brought to notice a number of systems, not merely in a primitive, but seemingly in an embryonic stage of development. The periods of occulting stars are nearly all of less than seven days, although one extending to thirty-one has lately been recognised; and the comparative length of the intervals of obscuration shows them to be produced by the circulation in narrow orbits of voluminous globes. These are characteristic symptoms of juvenility; since, as we have seen, orbits widen and periods lengthen with the efflux of time, through the frictional power of bodily tides. Now the class of stars which obviously and certainly undergo eclipses has some outlying members of a still dubious nature. And their critical position serves greatly to enhance the present, the prospective, and the retrospective interest attaching to them. These remarkable objects vary in light continuously. Their phases are not, like those of Algol, mere interruptions to a regular course of steady shining. They progress without a moment's sensible pause; they are represented graphically by a smoothly-flowing, symmetrical curve. The eclipses by which they are occasioned—if they are so occasioned—must, accordingly, succeed each other in a strictly unbroken series. No sooner has one terminated than the next commences. One star passes first behind, then in front of its companion, and their combined brightness is seen undimmed only during the few moments of actual maximum. This means that they revolve in contact; they are separated by no sensible gap of space.

Goodricke's variable, β Lyræ, is held to be thus constituted. The possibility, at any rate, of employing the "satellite-theory" to account for its changes was demonstrated some years ago by Mr. G. W. Myers, of Indiana.* He found the system to be composed of two barely separated ellipsoids, circulating in the visual plane, and producing, by their successive transits, two unequal eclipses in the course of each period of 12·91 days. The joint mass of the pair is just thirty times that of our sun; but their mean density has the almost incredibly small value of $\frac{1}{1200}$ that of water. Their real existence is conditional upon the possibility that masses much more tenuous than atmospheric air should radiate with the intensity of true suns. Spectroscopic observations are not wholly unfavourable to Mr. Myers's hypothesis, but their interpretation is hampered by discrepancies so numerous and perplexing that no secure inference can be derived from them. Moreover, the star supposed to be alone presented to view at the principal minimum is that giving the bright-line spectrum; yet it is compulsorily assumed, in order to meet the exigencies of the situation, to be much more massive, while much less intrinsically bright than its companion. This is disquieting; but nearly everything connected with β Lyræ *is* more or less disquieting.

* *Astrophysical Journal*, Vol. VII., p. 1.

A variable of the same type, but much fainter, was made the subject of a similar enquiry by Mr. Myers in 1898.* U Pegasi never attains ninth magnitude; hence spectroscopic complications equally with spectroscopic verification remain at present out of sight. The star, nevertheless, excites keen interest, and claims sustained attention. Its light-curve has been laid down with exquisite accuracy at Harvard College, and shows two slightly unequal minima to be comprised within a period of nine hours, signifying, on the adopted theory, the occurrence of alternating eclipses at intervals of $4\frac{1}{2}$ hours. The distance from centre to centre of the occulting stars, the smaller of which is of about eight-tenths the brightness of the larger, "does not materially differ," Mr. Myers tells us, "from the sum of their radii, suggesting the probable existence of the 'apioidal' form of Poincaré." If they do not actually coalesce, the component bodies revolve in contact, and rotate synchronously. Thus it is hard to say whether U Pegasi should be accounted as a single pear-shaped mass spinning in the time of light-change, or as a close couple circulating freely in an identical period. The mean density of the system appears to lie between one-third and one-fourth that of the sun.

Another specimen of the "dumb-bell" system is perhaps met with in R^2 Centauri. The narrow range of its variation makes it a delicate object to observe; but Mr. A. W. Roberts, who first noticed its peculiarity in 1896, has since accumulated an extensive series of wonderfully accurate visual determinations of its fluctuating brightness, and has besides rendered them the basis of an able and exhaustive theoretical discussion.† The double period of R^2 Centauri is restricted to 14h. 32m. Within this brief span quadruple phases are included—that is to say, two evenly-balanced maxima, and two inconsiderably disparate minima. These result, Mr. Roberts concludes, from the mutual eclipses of interpenetrating ellipsoids, one somewhat more luminous than the other, revolving—if they can properly be said to revolve—in an orbit inclined 32° to the visual plane. They are of just one-third the solar density, and the forms satisfying photometric requirements by the varying areas of luminous surface presented to sight in different sections of their path show a surprising agreement with the bi-prolate figure given by Prof. Darwin's analysis as the shape of a body on the verge of disruption through accelerated rotatory movement. The inference is, then, almost irresistible that R^2 Centauri really exemplifies the nascent stage of binary stars. To establish this completely, however, spectroscopic data are needed; and they are difficult to procure for a star below the seventh magnitude.

No such obstacle impedes the investigation of the analogous, but much brighter star V Puppis. Detected as a spectroscopic binary by Prof. Pickering in 1895, this star traverses so wide an orbit in the short period of thirty-five hours as to imply—if the published details are correct—that the pair possess no less than 348 times the gravitational power of the sun. They are, nevertheless, according to Mr. Roberts, fifty times more tenuous, and each globe should have a diameter of about $16\frac{1}{2}$ million miles; all which, though startling, is not incredible. The light-curve of V Puppis, as traced by Mr. Roberts, is closely modelled upon that of U Pegasi. And he postulates similar conditions of eclipse. It rests, however, with the spectroscope to determine whether those conditions are realised or not.

Probably all short-period variables are binaries, with coincident orbital- and light-cycles. But all are not occulting binaries. There are some—we are still ignorant of their proportionate numbers—which undergo a course of light-change, apparently compatible with an occulting hypothesis, yet certainly escape eclipse. Prof. Campbell has made it unmistakably clear that ζ Geminorum is thus constituted.* Two stars are present, but their plane of motion is inclined at an unknown angle to the line of sight; it does not approximate to coincidence with it. Now the possibility is not excluded that V Puppis belongs to the same class. Mr. Roberts's assumptions are indeed in themselves extremely plausible, and they may at any moment be proved, by a few well-timed spectrographs to be undeniably true. The one conclusive test is the cessation of radial movement at epochs of minimum. Evidently, if the diminution in lustre be in fact due to an eclipse, the eclipsing and eclipsed bodies must be crossing the line of sight just when the obscuration is deepest. There is no evading this geometrical requirement; and it must be rigorously complied with in the circular orbits traversed by bodies revolving in contact. Before, then, Mr. Roberts's theory of V Puppis can be accepted with implicit confidence, it has to be ascertained whether a zero of radial speed is reached concurrently with the photometric minima. If so, they may be unhesitatingly accounted eclipse-phenomena; if, on the contrary, the decline in brightness prove to be unrelated to a slackening of speed, then the supposition that it accompanies and indicates a transit must be peremptorily discarded. Moreover, the spectroscopic verdict as regards V Puppis can safely be applied to stars with similar light-curves, especially to R^2 Centauri and U Pegasi, and may serve to clear away some of the intricacies connected with the exceptional system of β Lyræ. The measurement of a single spectrographic plate might thus be made essentially to supply the lack of many desirable, but at present unattainable, determinations.

The existence of stellar systems of the "dumb-bell" type would violate no mechanical law. "Roche's limit" does not apply to globes comparable in size. The range of disparity within which it holds good has not, it is true, been theoretically established; but it may be said, in general terms, to concern the relations of planets and satellites (to use a purposely vague phrase), not those of double stars. What the law asserts is that a subordinate small body cannot, if their mean density be the same, revolve intact at a less distance than 2·44 radii of its primary from that primary's centre. For satellites of slighter consistence the limit should be extended. Our own moon, for instance, could never have circulated, without being rent in pieces by tidal strains, in an orbit less than 22,000 miles in diameter.† Bodies of co-ordinate mass are, however, exempted from the prohibitive rule against mutual approach. No analytical veto is imposed upon the origin by fission of double stars, or upon the subsistence of stellar Siamese twins. The inequalities in attractive power of co-ordinate masses avail for distortion, not for disruption. Their individuality, therefore, once created, is in a manner indestructible. It tends, in fact, to become more pronounced as the orbital span gradually widens through tidal friction. The "dumb-bell" condition may, accordingly, be, comparatively speaking, transitory. Nor can we be assured of its subsistence otherwise than by the peculiar nature of the eclipses attending upon it, taken in connection with spectroscopic observations of decisive import. The disclosure, by such means, of systems so strangely conditioned, affords a deeper insight than would else have been possible into the cosmical order, and fills a blank page in the genetic history of the sidereal world.

* *Astrophysical Journal*, Vol. VIII., p. 163.
† *Monthly Notices*, Vol. LXIII., p. 627.

* *Astroph. Jour.*, Vol. XIII., p. 90; *Science*, July 27th, 1900.
† G. H. Darwin, "The Tides," p. 325.

Notes.

Astronomical.—Another contribution to the study of the relation between solar activity and terrestrial magnetism was set forth by Father Cortie in a paper read at the recent meeting of the British Association. The point to which special attention was given was to determine if large and violently eruptive prominences, in the absence of spots, were responded to by magnetic disturbances and from a discussion of the prominence observations for the years 1887-88 it was found that in no single case could a magnetic storm be definitely associated with any particular prominence outburst, while great eruptive prominences occurred with no accompanying magnetic storm. It is concluded that the earth's magnetism is not affected directly by any particular spot or prominence, but by the general disturbance of the sun and his surroundings.

In an interesting letter to *The Observatory*, Mr. J. E. Gore draws attention to a description of Sirius given by Al-Sûfi, the Persian astronomer in the tenth century. It is stated that "the Arabians call the brilliant and great star which is in the mouth *al-schira al-abûr*, Sirius which has passed across. . . . It is called *al-abûr* because it has passed across the Milky Way into the southern region." Mr. Gore points out as a remarkable fact that the proper motion of Sirius (1″·31 per annum in the direction of position angle 204°) would have carried it across the Milky Way in about 60,000 years, and suggests that a mythological story related by Al-Sûfi as to why Sirius fled towards the south may be based on a tradition of Sirius having been seen on the opposite side by men of the Stone Age. At all events, the Arabic name *al-abûr* denotes an actual fact. Al-Sûfi further says that when Sirius passed across the Milky Way, Procyon remained in the region to the north-east of the Milky Way, which is also accordant with the known amount and direction of the proper motion of this star; 60,000 years hence, Procyon will also have crossed the Milky Way.—A. F.

Method for Ascertaining the Moon's Age.—Mr. Holmes' method for ascertaining the moon's age may be explained in the following manner. It depends, first of all, on the "Metonic cycle." Nineteen solar years correspond to 235 lunations; hence the new moons in one year correspond to those in the years 19 years earlier or 19 years later. This gives the first part of the rule, the effect of which is to divide all years into 19 classes, and corresponds in effect to the finding of the "Golden Number." The relation of any one year of a Metonic cycle to the next year of that cycle is given by the "Epact"—the age of the moon on the first day of the year. Since twelve lunations include 354 days, and a solar year 365 days, the epact of any year is 11 days greater than that of the preceding year. When the epact amounts to more than an entire month, only the odd days are counted. This gives us, in effect, the second part of the rule. There remains only the last part. January and February together make up two complete lunations. For the remaining months of the year, each is on the average one day longer than a complete lunation, so that the day of the new moon, *on the average*, falls one day earlier in each month after March. The year 1900 is divisible by 19 without remainder, and in this year the first new moon fell on January 1, so that for the month of January the day of the month gave at once the age of the moon. The rule then follows from the above principles. It is necessarily quite a rough one, and will often be two days in error, but as an instantaneous way of getting an approximate idea of the moon's age, it has its use.—E. W. M.

Zoological.—Those of our readers who studied the articles on "The Palaeontological Case for Evolution" recently published in this journal should be interested in a memoir on the ichthyosaurs, or fish-lizards, of the Triassic strata of California, issued in the *Geological Bulletin* of the Californian University. Compared with their descendants of the Lias, these Triassic species were quite small. Their most interesting feature is, however, the structure of the paddle, in which the component bones are much more elongated, and therefore less unlike the corresponding elements of normal reptiles, than are those of the true ichthyosaurs of the Lias. An important step is thus made in tracing the origin of the group.

Unlike chimpanzees, which have long since been recorded from Uganda, gorillas have hitherto been supposed to be confined to the west coast of Africa. Much interest attaches therefore to the discov ry of a representative of these apes high up on Mount Kirunga, nearly midway between Lakes Albert Edward and Kivu. Dr. Matschie, of Berlin, has described the animal as *Gorilla beringei*.

Mr. Pycraft's memoir on the osteology of owls, recently published in the *Transactions* of the Linnean Society, is an important contribution to our knowledge of birds' skeletons. Had we to deal with the skeleton alone, it is probable that owls would never have been separated in systematic zoology from the diurnal birds of prey. The soft parts are, however, very different in the two groups, and all the evidence points to the near affinity of the owls to the goat-suckers. Very curious is the discovery that the Nepalese horned owl differs from all its relatives in regard to the notching of the breast-bone. Whether, however, this necessitates its reference to a genus apart, may be a matter of opinion.

Some years ago an article, by Mr. Lydekker, appeared in this journal on the nursing habits of frogs. In the October issue of the Zoological Society's *Proceedings*, Mr. Boulenger describes the mode in which the eggs are carried by the female of a rare frog (*Ceratohyla bubalus*) from the Peruvian Andes. In the one specimen obtained with eggs, there were nine of these tightly adhering to the skin of the back, in which the spines of the vertebræ were so prominent as to leave indentations in the egg-membranes. Fully-formed young frogs were seen in the eggs.

Errata.—In Mr. A. C. D. Crommelin's articles on Cycles of Eclipses in Knowledge for September, p. 205, 2nd column, 5th line from bottom, for "N. Dec. 92° 27′," read "N. Dec. 9° 27′"; for October, p. 226, description under Plate IV, for "1085 years earlier," read "1805 years earlier."

British Ornithological Notes.

Conducted by Harry F. Witherby, F.Z.S., M.B.O.U.

Sooty Tern (Sterna fuliginosa, Gm.) in Suffolk (*Field*, October 3rd, 1903, p. 600).—Mr. W. A. Dutt here records that he lately found a fine adult specimen of this Tern in the possession of Mr J. Nunn, of Santon, Downham. The bird was found dead at Santon Downham Warren in the spring of 1900. Mr. Thomas Southwell has confirmed its identification. The Sooty Tern is an inhabitant of the Pacific, but it occurs as far west as the Indian Ocean and the Red Sea. It is a rare wanderer to Europe, and has only been recorded three times, previously to the above instance, in England.

Dartford Warbler in Shropshire (*Zoologist*, 1903, September, p. 349).—Mr. H. E. Forrest records that a pair or two of Dartford Warblers has been found breeding near Ludlow, in Shropshire, this summer. This is a north-western extension of the known breeding range of this bird. It is a species easily overlooked, owing to its secretive habits, and it is quite probable that Dartford Warblers have long made use of this newly-found breeding place.

Tree Sparrow in Shetland (*Ann. Scot. Nat. Hist.*, 1903, p. 211) *and in the Isle of Man* (*Zoologist*, 1903, p. 313).—For some years the Tree Sparrow has been extending its range. Fifty years ago it was unknown in Ireland, but it is now resident and increasing in numbers there. Mr. F. S. Graves now reports it from the Isle of

Man, where it probably breeds, and Dr. T. E. Saxby finds a pair nesting in West Shetland.

Wigeon Breeding in Ireland—A Correction (*Irish Naturalist*, 1903, October, p. 275).—In 1901, Mr. Robert Patterson recorded that the Wigeon had bred near Belfast (*see* KNOWLEDGE, 1901, pp. 183 and 205). A bird was flushed from one nest, but was not identified apparently. Mr. Patterson now frankly admits that a mistake has been made, and that the record must be cancelled. The eggs and the down agreed with those of the Wigeon, but through Mr. Heatly Noble, Mr. Patterson has learnt that the down is not always a reliable test for the identification of duck's eggs, and an examination of the small feathers mixed with the down from this nest has proved that they belonged to the Shoveler.

An Unknown Warbler in Oxfordshire. By W. Warde Fowler, M.A. (*Zoologist*, 1903, September, pp. 343-348).—In these days of the rigid protection of birds this article should prove instructive to those who favour extreme protection, as well as to the ornithologist. Mr. Warde Fowler and several of his friends have been watching for the last three years a small Warbler in a wood near Oxford. They have been quite unable to identify the bird, and would not shoot it, and the results of their observations are detailed at length by Mr. Fowler in the hope that some one may be able to identify the bird by the details given. From a scientific point of view these observations are quite worthless without the identification of the bird, which is impossible from the details obtained. Much personal pleasure was enjoyed, no doubt, by the observers in watching the bird, and in collecting these details, but those who advocate protection at all costs should bear in mind that without the knowledge of birds obtained by systematic study, as well as by observation in the field, protection of birds would never have been possible.

All contributions to the column, either in the way of notes or photographs, should be forwarded to HARRY F. WITHERBY, *at the Office of* KNOWLEDGE, 326, *High Holborn, London.*

Letters.

[The Editors do not hold themselves responsible for the opinions or statements of correspondents.]

RADIUM AND THE SUN'S HEAT.

TO THE EDITORS OF KNOWLEDGE.

SIRS,—The interesting article on radium in KNOWLEDGE for October prompts me to inquire whether the heat-giving property of its complicated atom can be called in aid to explain more satisfactorily the source of the sun's heat? Do we see any analogy at all between this minute atom and the mighty globe of the sun in their heat-giving and heat-maintaining properties? Or does the discovery of the new element explode the present theory of the source of the sun's heat? P. J. DAMANIA.

2nd October, 1903.

[There is no doubt that the discovery of radium compels us to abandon completely some of the conclusions, based upon present theories of the origin of the sun's heat. Mr. W. E. Wilson calculates that "3·6 grammes of radium per cubic metre of the sun's volume would supply the entire output" of the sun's energy. He further suggests that at the temperature of the sun, radium may be much more energetic than at our terrestrial temperatures. If so a much smaller weight of radium per cubic metre may suffice. The computations which Lord Kelvin and other leading men of science have made as to the possible length of time in the past, and in the future, during which the sun could maintain its present energy of radiation, are necessarily entirely set aside, for we can no longer assume that the concentration of the sun's substance from infinite distance has been the sole or even the chief source of its energy. It is not only that radium itself may exist in sufficient abundance in the sun to account for its energy, but the same or similar radio-active properties may be possessed by other of its elements, or by the sun itself as a whole. Prof. G. H. Darwin writes: "Knowing as we now do that an atom of matter is capable of containing an enormous store of energy in itself, I think we have no right to assume that the sun is incapable of liberating atomic energy to a degree at least comparable with that which it would do if made of radium" (*Nature*, 1903, September 24th, p. 496).—E. WALTER MAUNDER.]

THE LEONID METEORS AND THE MOON.

TO THE EDITORS OF KNOWLEDGE.

SIRS,—An investigation into the circumstances connected with the occurrences of the Leonid star-showers shows that there subsists the following relationship between these phenomena and the moon. All the Leonid meteor-showers on record have taken place either at or between new moon and first quarter, or else at or between full moon and last quarter, with the lunar perigee generally placed at or between full and new moon, the intensity of the phenomenon being greater the nearer the perigee and moon were to her phases of new or full. In the following table a list of these historic star-showers, as given by Prof. Newton in the "Encyclopædia Britannica," Vol. XVI., p. 110 (9th Edition), is presented, together with the positions of the moon and perigee at the time of each display:—

Date of Shower.	Moon New ● or Full (○). (Nearest to Shower.)		Moon in Perigee.
902, Oct. 13 (O.S.)	○ Oct. 20	(O.S.)	Oct. 21 (O.S.)
931, Oct. 15 ,,	● Oct. 14	,,	Oct. 13 ,,
934, Oct. 14 ,,	● Oct. 11	,,	Oct. 18 ,,
1002, Oct. 15 ,,	● Oct. 9	,,	Oct. 8 ,,
1101, Oct. 17 ,,	● Oct. 24	,,	Oct. 25 ,,
1202, Oct. 19 ,,	● Oct. 18 (○ Nov. 1)	,,	Nov. 1 ,,
1366, Oct. 23* ,,	○ Oct. 19 (● Nov. 3)	,,	Nov. 3 ,,
1533, Oct. 25 ,,	● Oct. 18	,,	Oct. 17 ,,
1602, Nov. 7 (N.S.)	● Nov. 14	(N.S.)	Nov. 5 (N.S.)
1698, Nov. 9 ,,	● Nov. 2 (○ Nov. 18)	,,	Nov. 18 ,,
1799, Nov. 12 ,,	○ Nov. 12 (● Oct. 28)	,,	Oct. 28 ,,
1832, Nov. 13 ,,	○ Nov. 8	,,	Nov. 12 ,,
1833, Nov. 13 ,,	● Nov. 11	,,	Nov. 8 ,,
1866, Nov. 14 ,,	● Nov. 7 (○ Nov. 22)	,,	Nov. 22 ,,
1867, Nov. 14 ,,	○ Nov. 11	,,	Nov. 14 ,,
1868, Nov. 14 ,,	● Nov. 14	,,	Nov. 9 ,,

* The moon became full in October, 1366, on the evening of the 19th.

The star-shower took place in each instance on the morning of the date given, and therefore local time is used. These displays occurred without exception at or between the time of new moon and first quarter, or else at or between the opposite lunar phases. Our satellite at the time of these showers was thus confined to two opposite quadrants which together equal one-half of her orbit. As far as it is a question of chance, the moon was just as free at any one of these showers to have been in the remaining half. It is excessively improbable, therefore, that this peculiar position of the moon in sixteen successive instances should have been due to mere coincidence. As regards the position of the perigee there is only one notable exception, viz., in the shower of 934, when the perigee was near the moon's first quarter. This display was of a feeble character, judging from the ancient account of it. We know from the records describing these phenomena (*American Journal of Science and Arts*, 1864, No. 111), that the showers of 1202, 1366, 1799, and 1833 far surpassed the others in brilliancy, and that the meteors were or must have been seen in tens of thousands. These intensely brilliant spectacles were witnessed at or immediately after the time of new or full moon. It may also be observed that at the time of the occurrence of the first three of these famous star-showers, the moon was moving in an orbit of almost maximum eccentricity, having been in perigee within a few hours of the time when she was new or full.

It is, perhaps, not surprising to find that the law which

thus appears to regulate the moon's position in the great meteoric phenomena, should also be illustrated in minor and irregular falls of Leonid meteors. Of all meteor-systems the Leonids exhibit the best-marked periodicity; but, as has been remarked by observers, shooting stars from Leo may make their appearance sometimes as much as a week before or after the mean epoch. Such of these minor or irregular displays as occurred before 1833 must have been by far the most remarkable, as they were not specially looked for, and, therefore, must have been of considerable splendour to have attracted casual observation. In the following table the dates of these displays, mostly taken from Arago's "Astronomie Populaire," Vol. IV., pp. 308-312, are given with the time when the moon was new or full and in perigee :—

Date of Shower.		Moon New (●) or Full (○). (Nearest to Shower.)		Moon in Perigee.
288, Sept. 28	(O.S.)	○ Sept. 27	(O.S.)	Sept. 21 (O.S.)
855, Oct. 18	„	● Oct. 15	„	Oct. 23 „
856, Oct. 18	„	○ Oct. 17	„	Oct. 16 „
1606, Nov. 15	(N.S.)	○ Nov. 14	(N.S.)	Nov. 3 (N.S.)
1787, Nov. 10	„	● Nov. 10 (○ Nov. 25)	„	Nov. 26 „
1813, Nov. 8	„	○ Nov. 8	„	Nov. 9 „
1818, Nov. 13	„	○ Nov. 12 (● Nov. 28)	„	Nov. 29 „
1818, Nov. 19	„	○ Nov. 12 (● Nov. 28)	„	Nov. 29 „
1820, Nov. 12	„	● Nov. 6	„	Nov. 17 „
1822, Nov. 13	„	● Nov. 13 (○ Nov. 28)	„	Nov. 29 „
1823, Nov. 13	„	○ Nov. 18	„	Nov. 21 „
1826, Nov. 7	„	● Oct. 31	„	Oct. 31 „
1828, Nov. 12	„	● Nov. 7	„	Nov. 14 „
1831, Nov. 13	„	○ Nov. 19 (7 p.m.)	„	Nov. 20 „
1832, Nov. 15	„	○ Nov. 8	„	Nov. 12 „

Prof. Kirkwood has given the date of the first of these displays, which he regarded as being connected with the present mid-November meteor-system. Arabic chroniclers mention the star-showers of 855 and 856; the shower in the former year was also seen in Europe on the night of October 17. The November star-shower of 1606 is thus described: "On a bright night, November 15, 1606, it seemed as though it rained stars; first fell only the largest and brightest stars from heaven, then indiscriminately the large and small stars in great numbers" [quoted in *American Journal of Science and Arts*, Vol. XXXVI. (2nd Series), p. 301].

It is seen that in these fifteen showers the moon conformed, with but one exception in 1823, to the rule shown to prevail in the more brilliant phenomena; the perigee, on the other hand, does not conform with the same exactness, and, as in the display of 934, the unusual position seems to affect the intensity of these minor meteor-falls. The peculiar position of the moon in all Leonid star-showers cannot be explained as due to moonlight, for the latter would as little diminish the splendour of a meteor display two or three days before as at, or a few days after new moon, and would certainly be far less troublesome a couple of days before full moon, than at or shortly after that phase; yet the moon in any of these great ancient or modern star-showers is never found in the second or fourth quadrants. It is remarkable that at the failure of the Leonids to appear on November 15th, 1899, the moon was within her second quadrant, and in her fourth at the Leonid epoch of November 15-16, 1900. With the moon in the first quadrant, moderately fine displays of Leonids were seen in America on November 15 in the years 1898 and 1901. It is remarkable that the lunar conditions at the Leonid epoch of 1766 resembled those of 1899, and that there is no record of a shower having taken place in the former year. The moon also happened to be unfavourably, or at least unusually, placed for meteor displays at the Leonid epochs of 1399, 1566, and many other occasions when important meteor-showers might have been expected to have occurred.

The conclusion which it seems to me is to be drawn from the foregoing coincidences respecting the position of the moon and the occurrence of Leonid star-showers, is that there is a meteor-swarm revolving round our planet, and that showers of shooting stars are produced from the perturbations of this meteor-ring under the combined action of the sun and moon. The velocity of shooting stars must be much lower than is generally supposed. Mathematicians at first assigned these bodies a velocity of 200 miles per second, a velocity that was subsequently abandoned only when it was found that gravitation failed to account for it. The heavier shooting stars, or bolides, have, however, in well-authenticated instances, been found moving at the rate of about 4 miles per second.

JOHN R. HENRY.

Dublin, September 15th, 1903.

CURIOUS SUNSET PHENOMENON.

TO THE EDITORS OF KNOWLEDGE.

SIRS,—I think that the phenomenon described in the September number of KNOWLEDGE by Lieut. Field must be what is commonly called in Canada a "Sun-Dog" We see them frequently in the *winter*, and usually accompanied by cold weather. I have only noticed them when the sun is a few degrees above the horizon; sometimes the sun is obscured, as noted by Lieut. Field, at others the sun is shining brightly and there is merely a slight haze of ice crystals. I think the Sun-Dog is a branch of the phenomena classed under the general term of "halos and parhelia," which are caused by refraction of the sun's rays through floating particles of ice. Just why the halo should take more than one form it is hard to say, though I am inclined to think that the ice crystals, being rhombohedral in form, would have a tendency to make their "refraction products" more complicated than in the case of the simpler raindrop; one can imagine the ice crystals all lying in one direction at one time and in another at some other occasion, or having the sun's rays refracted first through one layer of ice particles and then through a second.

At the elevation of Lieut. Field there would be every chance of there being a screen of ice crystals between him and the sun, although the temperature at the point of observation was a long way above the freezing point. I have often noticed a solar halo in the cirrus clouds when the temperature of the surrounding air was above 32° F. In his case he was looking horizontally through the layer of cold air; in the case of the solar halo I refer to, one is looking upwards.

PAUL A. COBBOLD.

Haileybury, Ontario, Canada.
September 14th, 1903.

THE PURPLE FLOWERS OF THE WILD CARROT.

TO THE EDITORS OF KNOWLEDGE.

SIRS,—I find in one of the *Umbelliferæ*, which I believe to be *Daucus*, a single central floret of different colour from the rest. I have to-day seen it pink and dark-red. And in Scotland I was shown some that were dark blue or purple. Is it usual, and does it occur in any other members of the family?

E. A. BURCHARDT.

Brashfield, Bicester,
15th September, 1903.

[The central flower, or several flowers, of *Daucus Carota* is frequently of a deep-red colour—generally, in fact, is a well-developed umbel. No similar feature is found in any other British umbellifer. I am not aware that any explanation of this curious feature has been put

forward. The natural assumption appears to be that it is connected with the "advertising department," that in some way it makes the flower-head more conspicuous to insects, and thus helps cross-fertilization. There are numerous instances of *white* flowers being used for this purpose (*e.g.*, in the Daisy), but I cannot think of an instance where the abnormal flowers are *dark*. —R. Lloyd Praeger.]

MAN'S PLACE IN THE UNIVERSE.

TO THE EDITORS OF KNOWLEDGE.

Sirs,—Will you allow me to express my dissatisfaction with Mr. Maunder's article in your current number upon the above question? Dr. Wallace's position, as to our place in the universe, is, that whatsoever evidence we have goes to support the conclusion that we are placed in or near the centre of the stellar universe; and that the universe itself is limited in extent. For the first point, Dr. Wallace has the support of the following evidence adduced by Sir Norman Lockyer:—"The stars in question in the Milky Way, which is a great circle, are all equally remote; and the only place where such a state of things can be observed must be a point equally distant from all, that is, in the centre of the system under observation. It is worth while to repeat, that because we are in the centre, because the solar system is the centre, that the observed effect arises" (*Nature*, November 8th, 1900).

For the limited dimensions of the universe there is the dynamic principle adduced by Lord Kelvin to show that the velocity of the stars in their drift is only compatible with a universe of limited dimensions. Now it is a very unsatisfactory reply to these things to speak of what *may* be, which, moreover, is a very unscientific position to take.

Maidstone, October 9th, 1903. W. Woods Smyth.

[Neither Sir Norman Lockyer's nor Lord Kelvin's arguments in the least support Dr. Wallace's position. Mr. Woods Smyth must remember that the whole object of Dr. Wallace is to prove that our solar system is the *only* one in which intelligent life is possible. He assumed that if he could prove that our sun was in the centre of the universe this would follow. It was a mere assumption, which he has practically withdrawn; but let that pass. Admitting its validity, it was still necessary for him to prove that our sun was much nearer to the centre of the universe than was the case with any other sun whatsoever. Neither of the two authorities quoted help him here.—E. Walter Maunder.]

STELLAR SATELLITES.

TO THE EDITORS OF KNOWLEDGE.

Sirs,—Mr. Gore, in his article under above title, in Knowledge for September, refers to the companion to Procyon. I think Burnham with the 36-inch failed to see this at all from 1888 to 1891 (see *Lick Publications*, page 63). Has it been seen since? If so, by any one except Schaeberle?

Mr. Gore refers also to the double companion to Rigel. I think Burnham afterwards doubted his observation of 1871. At any rate he found it single in 1889–1892 (see *Lick*, page 43).

Mr. Gore refers to what he calls "this rule," that most of the known binaries are of nearly equal brightness. I think the use of such words as "rule" and "law" is often objectionable. They imply more than is intended. But in the case referred to is it not—so far as it is a fact—because unequal binaries are much more difficult to discover and to observe? I don't think there is sufficient evidence that they are less numerous.

In another instance he says there are some stars which do not show orbital motion "which are *known* to be physically connected." In the next sentence he says "they are most *probably* near enough to be linked together by the laws of gravitation." But does not knowledge transcend probability? If they are *known* to be physically connected, are they not more than probably linked together by gravitation?

Mr. Gore also seems to use the word brightness indifferently for quantity of light and surface brilliancy. I know this is a very common practice, but it is a very awkward one.

Mr. Gore's speculations are very interesting, and would be more so if the parallaxes he uses were reliable, but when he calls a parallax of 0″·054 only "somewhat" doubtful he uses a very mild expression about it.

Edwin Holmes.

Notices of Books.

"The Position of the Old Red Sandstone in the Geological Succession." By A. G. M. Thomson, F.G.S. (Leng & Co.)—This well-printed book has been issued with all seriousness, and with no "controversial intention" (p. 224). The author frankly styles his views "hypotheses," but unfortunately appears to be ignorant of the long discussion which has moulded geological opinion as to the position of the Old Red Sandstone. He is unaware that he might have quoted the illustrious name of Jukes in support of his proposal (p. 97) to regard the Carboniferous and Devonian strata as contemporaneous facies of a single system (see *Quart. Journ. Geol. Soc.*, Vol. xxii., 1866, pp. 367-9). Mr. G. H. Kinahan, boldly carrying out Jukes's suggestions, has, moreover, anticipated Mr. Thomson as regards the intercalation of Old Red Sandstone conglomerates in the Carboniferous system (p. 90). It might have been expected that an author so anxious to improve upon our present knowledge would at least consult our current text-books. Sir A. Geikie, for instance, stated the case clearly ten years ago in his "Text-book of Geology" (3rd edition, p. 778); and the expanded form in which his remarks now appear (4th edition, 1903, pp. 981-2) should prove still more instructive to Mr. Thomson. He will learn from those excellent passages that geologists in general do not regard the Old Red Sandstone as of necessity conterminous with the marine Devonian system; but he will also find that the continental evidence for independent Devonian and Carboniferous systems has long proved fatal to the hypothesis of Jukes. Mr. Thomson, however, with a fine disregard for both stratigraphy and palæontology, considers that the Silurian beds containing fish-remains, and the Devonian and Carboniferous systems, represent varying types of deposit which *began* to be laid down at the same time side by side (pp. 49, 70, etc.). The British Coal-measures are for him a huge drift-deposit, brought in suddenly from some other quarter of the globe. The Atlantic Ocean and the American Continent (p. 36) are held to have existed in the Palæozoic era. The evidence as to the vast extent of post-Carboniferous denudation in our islands (p. 59) is absolutely overlooked. We gather from p. 218 that the variety of fresh-water, brackish-water, and marine deposits recognisable in our coal-bearing strata have never been seriously examined by the author. Mr. Thomson writes modestly throughout, but he has entered the field with a disregard for pioneers which will hardly commend him to the scientific reader.

"Radium and Other Radio-Active Substances: Polonium, Actinium, and Thorium." By William J. Hammer. (Sampson Low.) 5s. net.—Few discoveries have ever been received with greater interest than that of the radio-active properties of radium and its congeners. In the first place, it appeals to the sense of the marvellous which is present in all of us, and this none the less that old and apparently well-established laws seem to be violated by it. A few milligrams of radium, we are told by Prof. Curie, when introduced beneath the skin of a mouse near the vertebral column, produced death by paralysis in three hours. The introduction of radium into the science of chemistry will produce—who knows what? Already Prof. Armstrong, "speaking as a chemist," can scarcely express his astonishment at the audacious physicists who are opening up a new world to

us. It has long been the dream of philosophers that matter is composed of some primordial substance, arranged in more or less stable configurations, which we term atoms; but to the chemist the atom must be absolutely indivisible, or where will the fundamental chemical definitions be? Meanwhile, the general public looks on with that kind of interest which may be defined as a lively sense of surprises to come. And truly the surprises come, not as single spies, but in battalions; so quickly, indeed, that a *résumé* of our knowledge, as it was last April, has already taken on an air of commonplace antiquity. Nevertheless, Mr. Hammer's pamphlet on radio-active substances is a welcome contribution to the literature of the subject. In the first place, it traces the "birth and growth and signs" of the new ideas which are leavening our knowledge; and this is a worthy task, for at present the fame of the Curies, well deserved as it is, bids fair to blot out all recollection of the patient toilers who took the first few steps in the new direction. In the second place, it simply bristles with accounts of experiments and facts of importance, and at present we require a good deal of experimental ballast to give us a feeling of stability. Lastly, Mr. Hammer directs attention to some lines of experimental enquiry which are like to be forgotten in the enthusiasm for radio-activity. The first ten pages of Mr. Hammer's pamphlet are devoted to the consideration of fluorescence and phosphorescence. Most of us have seen the glow-worm, and those who have travelled in warmer climates have been charmed by the scintillations of the firefly; yet how many reflect that in these animals Nature has solved the problem of the economical production of light, which up to the present baffles human intelligence? What would be the result if we, like the firefly, could produce light without heat, and therefore at about one four-hundredth of its present cost? Leaving this interesting enquiry unanswered, as it must remain till our knowledge is considerably increased, Mr. Hammer devotes the next thirty-two pages to radio-activity properly so called. Starting with the early experiments of Henry, Niewenglowski, and Becquerel, the development of our knowledge is traced up to the point at which Prof. Curie found that radium produces heat without any apparent chemical change. As to the physical explanation of this phenomenon, the author has nothing to say; indeed, it was not till after the date at which he wrote that the researches of Rutherford and Soddy, Sir William Ramsay, and Sir William and Lady Huggins gave us a clue. At present it appears that radium atoms spontaneously decompose, and produce, amongst other products, the gas helium. To this idea Prof. Armstrong objects that in the whole range of chemical knowledge there is no evidence of atomic disintegration occurring under earthly physical conditions. But what are we to think? Helium certainly appears where there was no previous trace of its existence, and that in a manner altogether incompatible with our accepted ideas of chemical action. In addition, Prof. Dewar finds that radium produces heat freely at the temperature of liquid air, and more freely still at the lower temperature of liquid hydrogen; at such low temperatures there is, in the whole range of our chemical knowledge, no instance of ordinary chemical action. We are, therefore, certainly bound on an excursion into the unknown, and must shape our theories according to our new lights. It is surprising, however, that no one, in an attempt to explain the unknown by the incomprehensible, has so far dragged the "fourth dimension" into the discussion of these results.

Mr. Hammer next devotes about twenty pages to the properties of selenium, and describes many interesting arrangements by which sound may be transmitted "on the wings of light." The action of light on selenium is scarcely less interesting than the radio-activity of radium, and its mode of action is at present scarcely less obscure. Perhaps the two will ultimately be found to be related phenomena.

Mr. Hammer concludes with a short description of the effects of ultra-violet light on various forms of disease. Here, at least, we are tempted to repeat the platitude that there is nothing new under the sun; for a physician of the time of Queen Elizabeth stated that red light was beneficial to patients suffering from small-pox, while sunlight was distinctly harmful. This result has been found, by Prof. Finsen, to be due to the action of ultra-violet light on diseased tissue; while it is in the last degree harmful to small-pox patients, it can be utilized with remarkable success in the cure of lupus and similar diseases. Whether radium emanations may be ultimately used with success in the treatment of consumption and cancer is not yet known; but where so much has already been done we at least have grounds for hope.

"HISTORY OF PHILOSOPHY." By William Turner, S.T.D. (Ginn & Company.) 12s. 6d.—As a text-book for the student of philosophy this volume should prove of real service, but the reader must be on his guard as to the obvious bias of the author. Compiled from the best authorities, this attempt to set forth the succession of schools and systems of philosophy may be commended for its informing order and admirable method. Comprehensive in its scope, it is clearly and lucidly written, while throughout the work the statements of doctrine are accompanied by valuable bibliographical references. And, finally, the book is furnished with an adequate index.

BOOKS RECEIVED.

Retrospect of the Development of American Pharmacy and the American Pharmaceutical Association. By Frederick Hoffmann, PH.D.

Observations of a Naturalist in the Pacific between 1896 and 1899. By H. B. Guppy, M.B., F.R.S.E. Vol. I. (Macmillan.) 15s. net.

Conduction of Electricity through Gases. By J. J. Thomson, D.SC., LL.D., PH.D., F.R.S. (Clay.) 16s.

Introduction to Metallurgical Chemistry. By J. H. Stansbie, B.SC., F.I.C. (Bristol: John Wright & Co.; London: Simpkin, Marshall.) 4s. 6d. net.

Minute Marvels of Nature. By John J. Ward. (Isbister.) 7s. 6d.

Protozoa and Disease. By J. Jackson Clarke, M.B.(LOND.). (Baillière, Tindall & Cox.) 7s. 6d. net.

Drawing. (Self Educator Series). By Robert Y. Howie, M.A. Edited by John, M.A., B.SC. (Hodder & Stoughton.) 2s. 6d.

Flowering Plants. By Charlotte L. Laurie. (Allman.) 2s. 6d.

Photography by Rule. By J. Sterry. (Iliffe.) 1s. net.

Galileo, His Life and Work. By J. J. Fahie. (Murray.) 16s. net.

Short Studies in Economic Subjects. By J. H. Levy. (Personal Rights Asson.) 1s. net.

Theoretical Geometry for Beginners. By C. H. Allcock. (Macmillan.) 1s. 6d.

Cassell's Popular Science. Edited by Alexander S. Galt. (Cassell.) 12s.

The Handyman's Book: Woodworking. Edited by Paul N. Hasluck. (Cassell.) 9s.

Electricity and Magnetism. By R. T. Glazebrook, M.A., F.R.S. (Clay.) 7s. 6d.

Museums Journal. Edited by E. Howarth, F.Z.S. (Dulau.) 12s. net.

Individual Immortality. By E. M. Caillard. (Murray.) 3s. 6d. net.

Life and Public Services of Simon Sterne. By John Foord. (Macmillan.) 6s.

Lessons in Physics. By Lothrop D. Higgins, PH.B. (Ginn.) 4s. 6d.

Maculay's Life of Samuel Johnson. Edited by C. L. Hanson. (Ginn.)

Practical Orthochromatic Photography. By Arthur Payne, F.C.S. (Iliffe). 1s. net

Journal of the Society of Comparative Legislation. Aug. (Murray.)

The Practical Photographer. Oct. (Hodder & Stoughton.) 1s. net.

Buddhism. Sept. (Rangoon: Hanthawaddy Printing Works.) Rs. 2.

Transactions of the Edinburgh Geological Society. Vol. VIII. (Simpkin.) 6s.

Addresses and Essays. By Ralph Waldo Emerson. (Rational Press Association.) 6d.

Jesus Christ: His Apostles and Disciples in the Twentieth Century. By Count Camille de Renesse. (Rational Press Asson.) 6d.

On the Relationships between the Classes of the Arthropoda. By George H. Carpenter, B.SC.(LOND.), M.R.I.A. (Dublin University Press.)

The Science Student's Note Book, 1903-4. 6d. *The Science Teacher's Pocket Book and Diary, 1903-4.* 1s. (Manchester: James Woolley, Sons & Co., Ld.)

Lenses for Photography. (Taylor, Taylor & Hobson, Ld., Leicester.)

The Scientific Roll. By Alexander Ramsay. (Sharland.) 1s.

The Reliquary and Illustrated Archæologist. Oct. (Bemrose.) 2s. 6d.

BABY BATS.

By R. LYDEKKER.

EVER since the days of Pliny it has been a matter of common knowledge that female bats are in the habit of carrying their helpless young about with them during their aerial flights for some time after birth. With the exception of one peculiar species, to which allusion is made in the sequel, the young bat always clings to the under surface of its mother's body, where it obtains a secure hold among the dense coat of hair. The precise

position in which the young bat supports itself when its parent is in flight does not appear to be recorded; but when in repose, in the case of fruit-bats, or "flying-foxes," at any rate, the baby bat hangs head-downwards on its mother's chest, as is well shown in a figure published some years ago in the *Proceedings* of the Zoological Society and reproduced in the "Royal Natural History."

By the older observers it was generally considered that bats commonly produced two young at a birth, as is testified by Pliny, who wrote that the female carried her twin offspring about with her (*geminos infantes secum deportat*). Later observations, however, led to the conclusion that this idea was erroneous, and that as a rule only one is produced in a birth. For instance, in the second edition of Bell's "British Quadrupeds" it is stated that "the examination not merely of British species, but of a great number of foreign ones, has convinced us that where more than one young one is produced it must be regarded as an exception to the general rule."

In an earlier passage of the same work occurs the following statement: "The female bat brings forth one or two young at a birth, which she nurses with great tenderness and care, carrying it about with her, and holding it enshrouded in her ample cloak, which preserves it from all intrusion." Apart from the question whether the grammar in this quotation is as accurate as it might be, it will be noticed that the author confines himself to the statement that the mother bat carries a single offspring about with her. What becomes of the other, in the case of twins, is not stated.

The late Dr. G. E. Dobson, in his time the greatest authority on bats, noticed that in certain species of fruit-bats the nipples of the males were much enlarged during the breeding season; and from this circumstance he started an entirely novel idea, which is expressed in the following sentences:—

"It is probable that where two young are born at a single birth, the male relieves the female of the charge of one (as the weight of two might render flight difficult or impossible), and at the same time performs the office of a nurse. It is well known that many species of bats have occasionally two young at a birth, but I have never found a mother with more than one clinging to her body. The size of the pectoral teats in many male specimens (though in none yet observed by me so large as in this species and in another case referred to above) led me to think that instances of the male performing the office of nurse are probably not uncommon among bats."

Whether this suggestion is true in the case of fruit-bats must be left for future observation to determine; but it is now practically certain that it will not hold good for the ordinary insectivorous bats, although, so far as I know, no case has hitherto been recorded where a female of any of the European species of bats has been actually seen carrying about her twin offspring. The interest that would attach to a well-authenticated instance of this nature may be commended to the attention of the readers of Knowledge.

If, however, instances of female bats carrying more than one baby offspring clinging to their bodies are unknown in Europe, they have recently been brought to light in America. And in these instances not only has the parent bat been seen loaded with the weight of twins, but actually with that of a quartette.

Till the date of the aforesaid discovery (to which brief allusion has been previously made in our "Notes" column), it was the universal belief that bats never produced more than two offspring at a birth. In the spring of 1902 the female of a common species of American bat (*Lasiurus borealis*) was, however, received at the British Museum, accompanied by a quartette of young ones, which were stated by the collector to be her own progeny. In mentioning the circumstance, the describer of this specimen (which happened to belong to a new variety) very wisely refrained from giving it full credence until further testimony was forthcoming.

Such evidence was not long in appearing; and it is now definitely known that not only *Lasiurus borealis*, but other species of the same genus, and probably those belonging to the allied *Dasypterus*, are in the habit of generally producing four young ones at a birth. And, what is more, these four young ones are habitually carried about by the female, although no one has apparently yet taken one of these bats thus loaded in actual flight. It was in June, 1902, that a female *borealis* was brought to the United States National Museum with her family of four still clinging to her body; and she was successfully photographed shortly before her death, one of these photographs being reproduced in the accompanying illustration.

Bats of the genera *Lasiurus* and *Dasypterus*, it is interesting to notice, differ from the majority of their kind in being provided with four nipples; and in the case of

Female and Young of Rough-tailed Bat.

the female brought to the New York Museum a young bat was tightly holding on to each nipple by its curiously hooked teeth, aiding its grip by including a tuft of its mother's hair. European bats, on the other hand, have but a single pair of nipples, from which it may be inferred that they never produce more than two at a birth. That such twins, when they occur, are, however, carried about by their mother, may be regarded as practically certain.

In the case of the New York specimens, the weight of the female was 11 grams, while the combined weight of the four offspring was 12·7 grams. At the time the young were less than one-third grown, and they would evidently have remained for a further period with their parent. How she could have managed to fly at the date of observation—let alone later on—with a burden exceeding her own weight, is a mystery. And yet there is little doubt that she must have been capable of flight when thus laden, as otherwise she could not possibly have procured food, unless, indeed, supplies were brought her by the male, which is highly improbable.

This instance, it may be observed, affords a warning against drawing inferences, like the one quoted above, with regard to the powers and habits of animals on wholly insufficient data.

Before dismissing this part of the subject, reference may be made to a peculiarity in the structure of the teeth of baby bats, which appears to be correlated with their abnormal mode of life. It is well known that in the majority of mammals the milk or baby teeth differ somewhat in form from their permanent successors, but the differences are comparatively small, and both series are of the same general type. In bats, on the contrary, the milk-teeth are utterly unlike those of the permanent series; being slender, with sharp, hook-like cusps—in fact, just such a type as would be adapted for obtaining a firm hold of the nipples of their parent while she is in flight. And there is every probability that this is their true function. Possibly, indeed, baby bats may hold on to the maternal nipples during the whole time that they are in the air, as was found to be the case with the young of the New York female. It is also significant in this connection that bats shed their milk-teeth at a relatively early age—not improbably at the time when they learn to shift for themselves.

Such, then, are the leading facts in regard to what is known of the nursery arrangements of ordinary bats. There is, however, one very remarkable—and, it may be added, very ugly—bat which has struck out a line altogether of its own in this respect, for a parallel to which we must go to the marsupials. The species in question is the naked bat (*Chiromeles torquata*), of the Malay countries, which is the only representative of a genus whose nearest relatives are the mastiff-bats of tropical America.

In this large and hideous species the thick skin is almost entirely naked, and thrown in the chief regions of movement into a number of deep wrinkles and folds. But its most peculiar feature is the presence on the chest and under the wings of large pouches in which are placed the nipples; these nursing pouches being present in both sexes. These pouches, writes Dr. Dobson, "are probably absolutely necessary for the preservation of the young, which could scarcely otherwise succeed in maintaining its hold on the naked body of the mother during flight. It is interesting to find these pouches developed in both male and female, for their presence in the former suggests the idea that, where two young are born together, the male may relieve the female of the charge of one of them."

So far as I can ascertain, nothing is known with regard to the breeding habits of this bat, and it is consequently quite uncertain whether twins are ever produced. Whether there is any truth in Dr. Dobson's suggestion must therefore, for the present at any rate, remain undecided. It is, however, quite conceivable that the presence of the pouch in the male may not be connected with the nursing function, but may be an acquired secondary sexual character analogous to the presence of horns in the females of many antelopes and the reindeer. So far as it goes, the case of the American *Lasiurus borealis* is against the theory that the males of any species of bat undertake the duties of a foster-mother, since it is clearly demonstrated that the weight of even four young ones is no hindrance to the activity of the female. From the nature of the case it would, however, be a very difficult matter to prove that Dr. Dobson's theory with regard to the naked bat is or is not true. To prove it true, a male must be taken with a young one in its pouch, while to demonstrate that it is false, a female must be captured with a pair of young bats in the same receptacle. And since it is highly likely that the birth of twins is a rare event (even if it ever occurs), the chances of either of these discoveries being made would appear to be extremely remote.

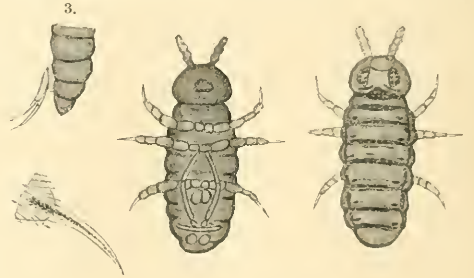
Apart from the question whether or no the male acts as foster-mother, the discovery of a naked bat with young in her pouch would be of extreme interest from another point of view. The young of ordinary bats are born in an advanced state of development, with their eyes open and their bodies covered with hair, as indeed is absolutely essential owing to the nature of their environment and the active muscular powers they have to exert soon after their entry into the world. But the young of the naked bat would seem to have no need either of protection from cold or of active muscular exertion during its sojourn in the nursing-pouch. Is it then born naked, or does it when just formed retain the hairy coat of the ancestral type from which it is descended? Some might even go so far as to suggest that the young of a bat thus specially protected as soon as it enters the world would be born in a helpless condition recalling that of young marsupials; but there are considerations which render this idea improbable.

MICROSCOPY

Conducted by M. I. CROSS.

"SPRING-TAILS."—While examining some duck weed (*lemna*), a number of minute black insects were noticed which continually jumped and sprang in all directions. These turned out to be specimens of *Podura aquatica*, commonly called "Spring-tails," a low type of insect life, in which the mouth parts have degenerated, a *collophore*, or sucker, has developed on the ventral side of the abdomen, and the caudal spines present in some nearly related species have been modified into an apparatus placed under the abdomen, which jerks the insect suddenly and sharply into the air. *Podura aquatica* is very small, $\frac{1}{24}$ of an inch long, and several can be kept alive in a cell and examined from time to time under the microscope. This is most interesting, as their movements are slow, except when the spring

3.



4. 2. 1.

FIG. 1.—"Spring-tail," *Podura aquatica*, dorsal view. FIG. 2.—Ventral view of *P. aquatica*, showing the mouth, the *collophore*, and the "spring" in its normal position. FIG. 3.—Lateral view of the posterior end of the insect, showing the position of the spring on being released. FIG. 4.—One of the claws, showing the gland and perforation.

comes into action, and their appearance grotesque and quaint. Sometimes they crawl on the surface of the cover-glass, and this gives an opportunity to examine the ventral side, and the spring and sucker. Both sides of the body are shown in the

illustrations, as well as a side view, showing the appearance of the spring after it has been released. The sucker is supposed to be used in resting, attaching the insect to an object; it is so rare in entomology, that those families possessing it, are grouped in the sub-order Collembola. The claws are also provided with a gland containing a viscid secretion, which runs down a minute perforation, and enables the "spring-tail" to adhere and walk on glass head downwards. After I had kept the insects about ten days several of them cast their skins. They are said to eat them, but mine did not. The cell alluded to can be made thus: Take a piece of thin wood or stout cardboard, two inches long by one broad. Out of one of the ends, punch or cut a hole, about half an inch from side to side. Cut several pieces of blotting paper the same size as a glass slip (three inches by one inch). Pink blotting paper must be used, as white is bleached by a chemical injurious to insects. Wet the blotting paper, place it on the glass slip; on this place the wood or cardboard in such a manner that the hole or cell is in the centre of the slip. After having placed the insects with some weed in the cell, cover the opening with a square piece of cover-glass. Keep the whole bound together with two elastic bands, or tie with thread. This cell, if the blotting paper is daily wetted, will keep the insects alive for a considerable time. The slip can be kept under a bell-glass to prevent evaporation.—W. Wesché, F.R.M.S.

Determining the Numerical Aperture of Dry Objectives.—Several suggestions have been made for rendering easy the exact determination of the N.A. of objectives, but the method attributed to Mr. Conrady, which appears in "Photomicrography," by E. J. Spitta, is probably one of the simplest.

Briefly, the system recommended is as follows:—Two pieces of white paper are laid upon a black background, their straight inner edges set parallel to one another at a convenient distance apart, say 20 cm. for lenses of ·5 N.A. and over, but less for low angled ones.

A scale, or some accurate means of measuring, is held vertically about mid-way between the two pieces of paper, and the objective to be tested placed vertically against the edge of the scale. It will now be noticed on examination of the back lens—the eye being placed at a distance about equal to the tube length, for which the objective is designed—that as the objective approaches the table the interval between the images of the two pieces of paper will widen until at last a point is reached where only a slight bluish flicker remains visible on either side at the extreme margin of the lens.

This is an indication that the inner edges of the pieces of paper are in the path of the most oblique rays that the objective is capable of receiving, and the angle between these two points, taken at the principal focus of the objective, is the angle of aperture.

This is now determined by reading off the vertical distance from the table to the front of the objective in this position and then subtracting the working distance of the lens so as to get the distance from table to focus.

This distance divided by half the distance between the two pieces of paper is the co-tangent of the semi-angle of aperture. The latter may be then obtained from a table of trigonometrical ratios, and the sine of the same angle is the N.A. of the objective.

This method has proved wonderfully accurate and rapid, and, without adding to the labour involved, an improvement may be effected by using the microscope for holding the objective and determining the various vanishing points by the rackwork.

It will then be a very easy matter to measure the distance between the sheets of white paper, which can be conveniently laid on a piece of black cardboard on the stage of the microscope in front of the objective.

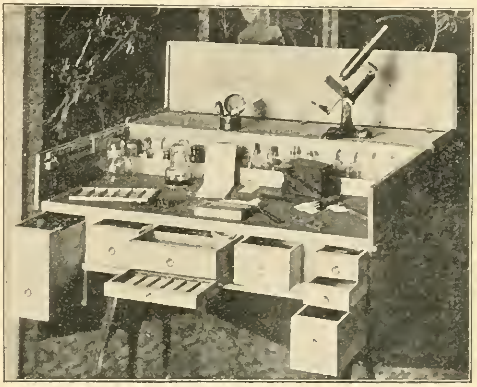
It also facilitates the measurement of the working distance of the lens. Of course no eyepiece would be used.

This system is applicable to dry lenses only.

Microscope Table.—In the number of this journal for November, 1902, some suggestions were made and devices invited for a microscope table, suitable for work in a restricted space, and in the January number a correspondent sent details of one that he was using.

We have since received further suggestions, but the best emanates from Mr. B. H. Morgan, and will be appreciated by reference to the illustrations herewith, one showing the table open and the other closed.

The table top measures 2 ft. 8 in. by 1 ft. 3 in., and with the top in position an extra shelf is available, 2 ft. 8 in. by 10 in.



Microscope Table.

This top rests on two brass tubes which push out from the sides.

The eight drawers vary in size, the largest will take 10 oz. bottles, and the smallest 3 in. by 1 in. slips.

The front is removed when in use, and when in position it is held by two dowels, and one lock secures the whole. Such a table could be mounted on a sewing machine stand, or on proper bench legs.

The advantages of such a table will at once be obvious, everything can be closed and left in position at a moment's notice, and dust is excluded.

Microscope Table.

Photographing Images in the Cornea of a Beetle's Eye.—There are probably few objects which create so much interest as the exhibition of multiple images in the cornea of a beetle's eye, and correspondents constantly write to inquire how the effect is produced.

I have previously indicated the method in these columns, and now in response to further requests, describe the manner of photographing those multiple images.

The following is a simple process:—The subject that is to appear in the facets of the cornea has to be made transparent, in other words a reduced negative has to be taken, and a transparent positive copied from it. A convenient size for this will be ¼ in.—⅜ in.

This may now be placed in the stop-holder of any condenser mount with, preferably, the condenser removed. All light should be blocked out around the transparency.

Either ½ in. or ¼ in. objectives may be used, and the instrument should be fitted to the photo-micro camera in the ordinary

way. It will be necessary to have in addition to the source of illumination a bull's-eye condenser.

Remembering that the images do not come into view in the same focal plane as the cornea itself, but in a higher one, the same as when viewing the images, the subject is focussed on the ground-glass screen of the camera, and the negative taken. Heads and busts of people seem to form the most suitable and popular objects with which to experiment.

Practical Scheme.—Through the kindness of Mr. A. H. Williams, of Hythe, we are able to offer a quantity of zoophyte material for distribution. Any readers desiring to avail themselves of this are invited to send a stamped addressed envelope, together with the coupon which will be found in the advertisement pages.

NOTES AND QUERIES.

A. Megson.—I am not quite sure from your letter whether you require a book on biology or on natural history; but if it is to have special reference to the numerous subjects which are available for microscopical examination, you cannot do better than procure "The Microscope and its Revelations," by Carpenter, edited by Dr. Dallinger, and published by Churchill. For Protozoa only you would probably find the work entitled "The Foraminifera: An Introduction to the Study of Protozoa," by F. Chapman, very helpful.

Communications and enquiries on Microscopical matters are cordially invited, and should be addressed to M. I. Cross, Knowledge *Office*, 326, *High Holborn, W.C.*

NOTES ON COMETS AND METEORS.

By W. F. Denning, F.R.A.S.

Borrelly's Comet (1903 c).—This comet is now visible only in the southern hemisphere as an exceedingly faint object. Some interesting reports of observations are given in *Popular Astronomy*. Mr. C. D. Perrine at the Lick Observatory writes that, with the Crossley reflector, a spectrum was obtained with a small slit-spectrograph on July 15, with an exposure of four hours. Five bands were shown similar to those photographed by Campbell in Rordame's comet of 1893, and Gale's comet of 1894. The brighter of the bands show evidence of composite character, although they are not resolved. Very little continuous spectrum is exhibited. Mr. H. D. Curtis observed the spectrum with the 36-inch refractor on July 14 and 15, and says that visually it showed a relatively strong continuous spectrum and three characteristic bands. Of these, that at λ 4700 seemed brightest. An attempt was made to photograph the spectrum, but the intrinsic brightness of the comet was too small. The comet itself was photographed on several occasions, and two tails appear on all the plates except the last (July 14). On June 30 the primary straight tail extended over 5 degrees, while the secondary curved tail had a length of 1½ degrees. On July 14 there was one straight narrow tail 8½ degrees long.

From observations of the same comet made by M. Deslandres at the Meudon Observatory, and reported in the *Comptes Rendus*, it appears that the spectrum was found of the characteristic hydrocarbon type, but in the region of the nucleus some additional bands were faintly exhibited. M. Deslandres thinks that the temperature of the comet is sufficiently high to bring about incandescence, and concludes that the spectrographic method is capable of increasing our knowledge of cometary physics by defining the structural motions of comets.

Brooks's Comet (1889 V.—1896 VI.).—Too faint to be observed in small telescopes, this periodical comet is now situated in the eastern region of Capricornus, near ϵ, and moving very slowly eastwards in a direction away from the earth, though its perihelion passage will not occur until December 11.

Giacobini's Comet (1896 V.).—Astronomers have been sweeping for this object, but apparently without success. It passed its perihelion in June. On October 28 its position is R.A. 3h. 55m., Dec. + 8° 7′, or about 10 degrees S.W. of the Hyades in Taurus, and the motion is extremely slow to S.W.

Meteoric Showers in September.—Not many meteors were observed in September this year, but the month is usually a productive one both of fireballs and ordinary shooting stars. In the morning hours at this period, swift, streaking meteors are sometimes very numerous, and their discursive flights afford evidence of an abundance of radiants distributed over the eastern quarter of the heavens. As a means of reference during future observations the following list has been compiled of the positions of the principal showers. These include the swifter class of meteors only; there are a considerable number of streams of slow meteors visible at the same season, but these are chiefly placed in the southern sky, and generally best observed in the evening hours:—

Radiants of Swift, Streaking Meteors, September 10–27.

°		°	°		°	°		°
48	+	44	77	+	32	105	+	59
55	+	71	78	+	57	107	+	12
56	−	12	80	+	24	111	+	24
57	+	9	86	+	34	115	+	83
60	+	49	87	+	42	118	+	31
61	+	36	87	+	57	123	+	62
63½	+	22½	88	+	19	127	+	58
71	+	3	98	+	43	130	+	46
74	+	42	100	+	13	134	+	37
75	+	15	105	+	51	156	+	41

The most active of these appears to be the one at 61° + 36°, near ϵ Persei.

The Leonids.—There will be little appreciable interference from moonlight in 1903, and the shower should be carefully looked for on the mornings of November 14 to 17. The conditions scarcely justify the anticipation of a plentiful display, but it may be confidently stated that the Leonids will return, if not in rich numbers, at least in sufficient strength to form a definite shower and to enable their point of radiation to be redetermined. That the stream is one of annual occurrence, like the August Perseids, is certain, though there is a marked distinction between the two, the Leonids being very thickly clustered near the parent comet and scantily dispersed over other sections of the ellipse, whereas the Perseids form a pretty rich and evenly strewn orbit capable of yielding a moderately strong shower every year.

Large Meteors.—Mr. A. C. Sykes, while at Wadbury, near Frome, Somerset, on September 12, 9h. 23m., saw a meteor brighter than Jupiter pass from a considerable distance above that planet to above and beyond Altair, the direction being from Andromeda. It descended at an angle of about 15° and left a luminous streak for 3 seconds. Probably the meteor was one of the ϵ Perseids. On September 23, at 12h. 30m., the writer, at Bristol, recorded a bright flashing meteor, which must have exceeded Venus, with a path from 78° + 58° to 127° + 77°, and a radiant at 63° + 23°. Its uneven streak remained visible about 15 seconds. It is to be hoped that this fine specimen of the September Taurids has been observed at other stations. The particular shower from near ϵ Tauri to which it belonged is a tolerably active one during the third week in September. On October 3 two meteors rather brighter than Sirius were observed at Cardiff at 10h. 5m. and 10h. 12m. respectively. The first moved from Perseus towards the Pleiades, and vanished about 3 degrees west of that cluster. The second travelled more slowly, and pursued a longer course, from Polaris to Capella. On October 13, at 9h. 20m. G.M.T., Mr. W. H. S. Monck, of Dublin, saw a meteor equalling Jupiter in apparent brightness. It passed slowly from a little below the double star-cluster in Perseus to between Capella and Ursa Major, and finally disappeared in that part of the Lynx bordering Ursa Major.

Detonating Fireball.—On Saturday afternoon, October 3, a large aerolite is reported to have fallen near Tain, in the north of Scotland. It appeared as a ball of fire, which burst immediately over the town, and gave a thunder-like report audible over a wide extent of the surrounding country. Doors and windows rattled in the villages of Eastern Ross, and the inhabitants were greatly alarmed. A telegram from Rogart, Sutherland, reports a shock of earthquake as having occurred at the same time, but this was certainly due to the detonation and vibration of the fireball.

THE FACE OF THE SKY FOR NOVEMBER.

By W. Shackleton, F.R.A.S.

The Sun.—On the 1st the sun rises at 6.53 and sets at 4.34; on the 30th he rises at 7.42 and sets at 3.54.

The solar disc is now rarely free from spots and faculæ; at the time of writing there is a spot-group of considerable size visible.

The Moon:—

		Phases.	H. M.
Nov. 5	○	Full Moon	5 28 A.M.
„ 12	☽	Last Quarter	2 46 A.M.
„ 19	●	New Moon	5 10 A.M.
„ 27	☾	First Quarter	5 37 A.M.

The moon is in perigee on the 10th, and in apogee on the 25th.

The more interesting occultations visible at convenient hours are as follow:—

Date.	Star Name.	Magnitude.	Disappearance. Mean Time.	Disappearance. Angle from N. Point.	Disappearance. Angle from Vertex.	Reappearance. Mean Time.	Reappearance. Angle from N. Point.	Reappearance. Angle from Vertex.	Moon's Age.
			h. m.	°	°	h. m.	°	°	d. h
Nov. 1	B.A.C. 8094	5·6	0 30 A.M.	77	43	1 34 A.M.	241	204	11 9
„ 4	ξ Arietis	5·5	6 36 P.M.	116	155	7 19 P.M.	205	243	15 3
„ 7	111 Tauri	5·2	11 10 P.M.	140	176	11 47 P.M.	205	238	18 7
„ 9	λ Geminorum	3·6	8 43 P.M.	62	98	9 28 P.M.	301	340	20 5
„ 29	44 Piscium	6·0	8 0 P.M.	81	79	9 16 P.M.	229	212	10 15

The Planets.—Mercury is in superior conjunction with the sun on the 21st, and throughout the month the planet is not suitably placed for observation, being lost in the sun's rays.

Venus is a bright and conspicuous object in the morning sky for some considerable time before sunrise, and throughout the month she rises rather more than four hours in advance of the sun. She attains her greatest westerly elongation of 46° 44′ on the 28th. With slight optical aid, she can easily be seen during the day, and as some guide to her position the following table gives the time she is on the meridian, and the altitude she attains:—

Day.	Time on Meridian.	Altitude.
1	9 A.M.	40°
10	8.52 A.M.	38½°
20	8.47 A.M.	35°
30	8.46 A.M.	32½°

The phase of the disc is nearly "half," answering to that of the moon about six days old; about the middle of the month the diameter of the disc is 30″.

Mars is not in a suitable position for observation, being low down in the S.W. shortly after sunset.

Jupiter is favourably placed for observation throughout the month; at the beginning of the month he souths at 8.20 P.M., and at the end at 6.30 P.M. In consequence of his increasing distance from the earth his apparent polar diameter has diminished to about 41″ with a corresponding decrease in lustre. The planet ends his retrograde motion in Aquarius on the 10th when he is at the stationary point; after this date his motion is again direct or easterly.

The configurations of the satellites as seen in an inverting telescope at 8 P.M. are as follow:—

Day.	West.	East.	Day.	West.	East.
1	4 2 1	○ 3	16	2	⊙ 1 3
2	4 2 1	○ 3	17	4	○ 3 2 ●
3	4 3	○ 1 2	18	4 3 1	○ 2
4	4 3 1	⊙	19	4 3 2	○ 1
5	4 3 2	○ 1	20	4 3 1	○ ●
6	4 3 1	○ 2	21	4	○ 1 2 ●
7	4	○ 1 3 2	22	4 1 2	○ 3
8	2 1	○ 3 ●	23	4 2	○ 1 3
9	2	⊙ 3 4	24	4 1	○ 3 2
10		⊙ 2 4 ●	25	3 1	○ 2 4
11	3 1	○ 2 4	26	3 2	○ 1 4
12	3 2	○ 1 4	27	3 1 2	○ 4
13	3 1	○ 4 ●	28		○ 1 2 4 ●
14		○ 3 1 2 4	29	1 2	○ 3 4
15	2 1	○ 4 3	30	2	○ 1 3 4

The circle (○) represents Jupiter; ⊙ signifies that the satellite is on the disc; ● signifies that the satellite is behind the disc, or in the shadow. The numbers are the numbers of the satellites.

Saturn is on the meridian shortly after sunset; about this time, therefore, is the best for observation, as he is low down and sets about 9 P.M. The distance of the planet from the earth is increasing, hence his brightness is diminishing. The diameter of the ball is 15″, whilst the diameters of the outer major and minor axes are 38″ and 13″ respectively; we are looking down on the northern surface of the ring at an angle of 20°, consequently the ring appears well open.

Uranus is approaching conjunction with the sun and cannot be observed.

Neptune rises about 7 P.M., near the middle of the month; he is not far from the star μ Geminorum, as shown on the chart given in the January number.

The Stars.—About 9 P.M., at the middle of the month, the following constellations may be observed:—

Zenith . Cassiopeia.

South . Andromeda, Pisces, Cetus; Pegasus, Aquarius towards S.W.

West . Aquila, Cygnus, Lyra a little north of west, Corona N.W., setting.

East . Auriga, Perseus, Pleiades, Taurus; Aries to the S.E.; Orion rising S.E.

North . Ursa Major, Ursa Minor, Cepheus; Draco a little west of north.

Minima of Algol will occur on the 7th at 11.23 P.M., 10th at 8.12 P.M., 13th at 5.1 P.M., 28th at 1.6 A.M., and 30th at 9.55 P.M.

Chess Column.

By C. D. Locock, B.A.

Communications for this column should be addressed to C. D. Locock, Netherfield, Camberley, and be posted by the 10th of each month.

Solutions of October Problems (P. H. Williams).

No. 1.

Author's Key.—1. Q to Q5.

[There is a second solution by 1. Q × Kt.]

No. 2.

Key-move.—1. Kt to Q7.

If 1. . . . K to Q4, 2. Q to QB5ch.
1. . . . B to B5, 2. Q to B3ch.
1. . . . Other moves, 2. Q to B3ch, etc.

Solutions received from "Alpha," 2, 4; W. Nash, 2, 4; G. A. Forde (Major), 2, 4; "Looker-on," 3, 4; W. H. S. M., 3, 4; G. W. Middleton, 3, 4; "Quidam," 3, 4; J. W. Dixon, 3, 4; C. Johnston, 3, 4; H. S. Brandreth, 2, 4; H. F. Culmer, 2, 4; T. Dale, 2, 4; E. M. Oakley, 2, 4; E. A. Servante, 3, 4.

Mr. Williams' two-mover has been the cause of Mr. W. Nash dropping a point behind the other three leaders. As we can hardly expect a two-move problem to perform the service of separation again this year, two three-move problems are given this month, and the same device will probably be tried next month.

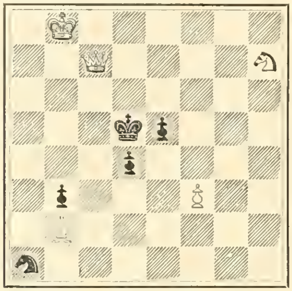
R. J. Bland.—Thanks for the game and problem. The former appears below, and I shall hope to find room for the latter during the winter.

PROBLEMS.

By J. W. Abbott.

No. 1.

BLACK (5).

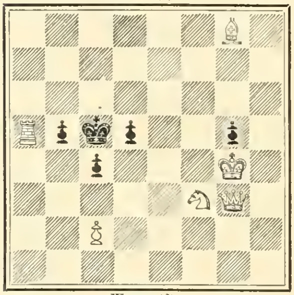


WHITE (5).

White mates in three moves.

No. 2.

BLACK (5).



WHITE (6)

White mates in three moves.

The following game was recently played by correspondence in India.

"Petroff's Defence."

WHITE. (R. J. Bland, Hyderabad.)	BLACK. (R. J , Bangalore.)
1. P to K4	1. P to K4
2. Kt to KB3	2. Kt to KB3
3. Kt to QB3	3. P to Q3 ?
4. P to Q4	4. P × P
5. Kt × P	5. B to K2
6. B to K2 (*a*)	6. B to Q2
7. P to KB4	7. Kt to B3
8. P to B5 (*b*)	8. Kt × Kt ?
9. Q × Kt	9. P to B4 ?
10. Q to Q3	10. B to B3
11. B to B3 (*c*)	11. Kt to Q2
12. B to B4	12. Kt to Kt3 (*d*)
13. Castles Q's side	13. Kt to Bsq
14. Kt to Kt5 !	14. P to QR3 (*e*)
15. Kt × P (ch)	15. Kt × Kt
16. B × Kt	16. Q to Q2
17. P to K5	17. R to Qsq (*f*)
18. Q to QB3 (*g*)	18. KB to Kt4 (ch) (*h*)
19. K to Ktsq	19. Q × P
20. B × B (ch)	20. P × B
21. Q × P	21. P to B3 (*i*)
22. P to KKt4 (*j*)	22. Q to K3
23. P × P	23. B to K6
24. P × P	24. Resigns. (*k*)

NOTES.

(*a*) Not 6. B to QB4, on account of the reply 6. . . Kt × P.

(*b*) On principle this should not be good, as it enables Black to establish a Knight at K4, besides leaving the White KP weak. Instead, 8. B to K3 would be a useful developing move. Black's reply is bad, and his next move, weakening the QP, still worse.

(*c*) To prevent P to Q4.

(*d*) Kt to K4 seems the obvious move here. The retrograde movements of the Knight result in a very cramped game, and the immediate loss of a Pawn.

(*e*) Black would equally lose a Pawn after 14. . . B × Kt, 15. Q × Bch, Q to Q2, 16. Q × Qch, K × Q, 17. P to K5, etc. But Castling would be better than the wasted move with the RP.

(*f*) He might as well get Castled on the Queen's side, and so leave the other Rook free. In addition he should exchange the distant Bishops

(*g*) The beginning of a good final combination, in which, however, as at many other stages, he is considerably aided by his opponent's weak play.

(*h*) After this he can no longer Castle. He should still exchange the other Bishops.

(*i*) He cannot well retire the Queen, on account of the threatened advance of the KP.

(*j*) Good enough, but perhaps KR to Bsq. is even stronger.

(*k*) For if 24. . . KR to Ktsq., 25. Q to R5ch, K to Q2, 26. B to B8 dis.ch. wins easily.

CHESS INTELLIGENCE.

The proposed match between Dr. Lasker and Mr. F. J. Marshall having fallen through, as might have been expected, the latter has found an opponent in Mr. Blackburne, who will play a match with him shortly. It is understood that Mr. F. J. Lee is also willing to encounter the American expert.

The Hastings Chess Club Team of ten players has recently concluded a very successful tour among the principal cities of Germany. Out of six matches played three were won, two lost, and one drawn. The one decisive defeat (at the hands of the Berlin Chess Association) was the result of a match not originally on the programme of the tour.

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CONTENTS.

EDITORIAL.

THE brilliant discovery of Radium stands out conspicuously as the most striking scientific event of the closing year, but on looking back one may note that 1903 has been marked besides by many solid advances in most branches of science. KNOWLEDGE, we may hope, has done its part, as has ever been the aim of its conductors, in helping to record these events, and in keeping its readers in touch with important researches in many directions. As in the past, so now, we pass our cordial thanks to contributors and subscribers alike for enabling us to produce this Twenty-sixth Volume of our Journal, while to the Press we would also express our indebtedness for many valued reviews of our work.

Looking forward to the coming year of 1904, and dealing first with Astronomy, which we are glad to find claims from year to year an increasing and yet more ardent band of devotees, we have to announce that Miss Agnes M. Clerke, to whom we have been indebted during the past year for five most informing essays on "Modern Cosmogonies," will contribute further papers on the same subject during the coming year. Mr. E. Walter Maunder will write a series of papers dealing with the Sun as a subject for observation with Small Telescopes, and the relation of Sunspots to various terrestrial phenomena. Mons. E. M. Antoniadi has kindly promised the services of his clever pen and pencil in illustrating the subject, and we feel sure that Mr. Maunder will find many interested readers who possess a small telescope, while others, who are not so provided, may be induced to equip themselves, and study the sun under his guidance. Other contributions in Astronomy will include an illustrated paper on Saturn by the Rev. T. E. Phillips, which will appear in the January number, and papers by Dr. Isaac Roberts, Messrs. J. E. Gore, W. F. Denning, and others.

The column hitherto devoted to Comets and Meteors, and so ably conducted by Mr. Denning, will be discontinued, but notes of prime importance in this subject, as well as in Planetary observations, are promised from time to time by Mr. Denning.

We regret to announce the retirement of Mr. M. I. Cross from the control of the Microscopy Columns, and take this opportunity of cordially thanking him for his most efficient and successful work during the past years. At the same time we are pleased to announce the accession to our ranks of Mr. F. Shillington Scales, whose ability to conduct the Microscopy section with success will be recognised by those interested in the science.

The increasing interest in physical subjects has led us to arrange with Mr. Edwin Edser for a series of papers on the Paradoxical Properties of Fluid Motion. In other subjects, Mr. W. P. Pycraft promises a few papers on some aspects of Evolution in Birds, and Mr. George Massee will write upon the habitats and distribution of Fungi, and their influence for both good and bad upon other forms of life. Mr. William Marriott will contribute some articles on Practical Meteorology, dealing with Temperature, Rainfall, and Sunshine; while Mr. R. Lydekker is providing some illustrated essays on Palæontological subjects, in which he will discuss the Ancestry of the Horse, the Camel, the Carnivoræ, and other mammals.

The Third Annual Competition for the Chess Challenge Trophy begins with the problems in the January number, where the conditions of the Tourney will be found. The contest for the year 1903 has been very close, the previous holder having fallen behind, and retired.

THE STRUGGLE FOR EXISTENCE IN SOCIOLOGY.

By J. Collier.

IV.

The Linguistic Struggle.

It is estimated that over 5000 distinct languages are spoken among men. A calculating prodigy would be wanted to compute with exactness how many separate dialects are in use. Sixty years ago it was reckoned that sixty different vocabularies were to be found in Brazil, but the actual number must be far greater, for in much smaller Mexico the Nahua language has broken up into 700 dialects. There are hundreds in Borneo. In Australia there is no classifying the complexities. And, generally, the number of dialects is in inverse proportion to the intellectual culture of the population. Assume that only fifty dialects on an average belong to every language, and we have the colossal total of a quarter of a million linguistic varieties. In this Babel the battle (what we call battle) is incessant. Could we examine the habitat of a language or a dialect as we watch the advancing or receding boundaries of a biological species, we should perceive its frontiers to be in similar continual movement, as now one and now the other gained the victory. All manner of inflections—numbers and tenses, cases and moods—likewise strive with one another for predominance. Modes of utterance dictated by differently modified laryngeal organs struggle for superiority. Unlike manners of arranging the written words are found to be mutually incompatible, and several succumb, while one survives here and another there. The visible transcripts of sounds gather into alphabets, and the cuneiform, ideogrammatic, syllabic, and literal contend on bloodless battlefields, where most of them perish or else live on in isolated environments. What are the laws of the conflict among all these groups? Canon Isaac Taylor affirms that "plainly the laws which regulate the survival of language do not conform to the same conditions as those which regulate the survival of race." If such were the case, either set of laws, or both sets, would be convicted of unsoundness or inadequacy. The laws of evolution are universal, or they are no true laws. The laws of survival are identical in all provinces of Sociology. They are the same as those which govern the survival of vegetal and animal species. We shall endeavour to trace the more important of them by following the various aspects of the linguistic struggle.

Among Alphabets.

The decipherments of the cuneiform syllabary by George Smith, of the Cypriote alphabet by the same scholar, and of the Hittite alphabet by Professor Sayce, shed gleams of light on a conflict among alphabets. The battlefield was Asia Minor and Hellas. The competing alphabets were the three named. The Assyrian syllabary was backed by physical force. The victories of Sargon and Assurbanipal had made the influence of Assyrian civilization felt in the islands and peninsulas washed by the Mediterranean. Yet it seems never to have been in the running at all. We are told that the triumph of Darwinism means the triumph of materialism. Here military conquest availed nothing to procure acceptance for an inferior script, belonging to one of the oldest forms of written language, in preference to less archaic types. The real battle was between two of these. Dr. William Wright and some auxiliary explorers have rescued from oblivion the existence and some portion of the history of an empire that occupied Northern Syria and Cappadocia between the eighth and twelfth centuries B.C. If not the Hittite language, at least the alphabet devised by that warrior people prevailed all over Asia Minor. Recently-discovered inscriptions reveal its true character. Many of its 125 distinct signs were ideograms—survivals of the picture-writing stage. It therefore stood midway between the cuneiform Assyrian and the phonetic Phœnician. It travelled south and west, through Lycia and Caria, Phrygia and Lydia, dropping some portion of its cumbrous structure at each halting-place. All of the alphabets used in these countries seem to have been derivatives of the Hittite, but apparently in all of them the ideographic element was abandoned, the language becoming more phonetic as it advanced. Arriving in Cyprus, it had left behind it more than half of its baggage. In Cyprus and Asia Minor a new struggle ensued. There the far handier alphabet which the Phœnicians had adapted from the Egyptian came into competition with the various tongues adapted from the Hittite. The clumsy Cypriote alphabet, with its 60 letters, most of its consonants having five different forms, and its lack of aspirates, could not in the long run stand against the simpler Cadmeian alphabet, but was maintained to the time of the first Ptolemies in a secluded environment by the authority of the priests. In Asia Minor, which was less closed to outward influences, the victory of the Phœnician alphabet was swifter. It expelled the Hittite alphabets, some of whose characters, however, lived on by the side of Phœnician to supplement its imperfections. No military force was at the back of the new alphabet. No priestly sanctions consecrated it. It had nothing in its favour but its simplicity and its convenience. It was propagated by a commercial people inhabiting a territory thirty miles long and a mile broad. Yet it spread over no small part of the world, driving before it hundreds of cumbrous syllabaries or forms of picture-writing. Its universal acceptance may be described as the triumph of utility.

A new factor in the linguistic struggle is disclosed by the battle at this moment being waged in Bosnia. Both sides speak the same language—Croat, but they write it with different alphabets: the Catholics with Roman letters, and the Orthodox with the Cyrillic. To symplify the task of the public teacher, the Austrian Government directed that the Latin alphabet should alone be used in schools. The innovation provoked a loud outcry from the Orthodox, who deemed it a blow to their religion. The Government had to yield, and once more in history physical force was worsted.

Another factor is revealed by the conflict in Germany between black-letter characters and the Roman alphabet. It is costly to keep two distinct kinds of type, and hence the inferiority of German typography. The strain of reading "Gothic" print doubtless also contributes to the myopia prevalent in Germany. Yet, though Roman is manifestly gaining ground, a perverted patriotism, long fostered by a Gothic spirit like Bismarck, maintains the archaic form.

Among Scripts.

Words were first written vertically or columnwise, and children are still taught to write as the Greeks, Hittites, and Egyptians wrote from three to ten thousand years ago. Test a boy, and he will be found to incline to the left. The deviation was regularised, and writing became horizontal. When the scribe got to the end of the line, instead of turning back to the right, he began in the space below at the side where he left off. It is almost the ploughman's way, and the Greeks named it "ox-turning-wise." Natural, simple, and easy as the plough-

mode seems, it was abandoned in favour of a variant on itself. One limb of the furrow was kept. From right to left was stereotyped as the conventional direction in the Orient, which never advanced beyond it; from left to right in the more business-like Occident. All four methods co existed among the Greeks, and in other countries there was a conflict between two or more of them. What gave the victory to the horizontal line and the rightward direction? Apparently a single consideration. The successive transitions followed the path of least resistance, and obeyed the principle of least effort.

Among Orthoepies.

The same imperious principle, aided by two unlike factors, decided a conflict between pronunciations. In the beginning of the sixteenth century Greek was pronounced in England as in Greece; until lately it was spoken as English is spoken. By what agencies was the change brought about?

1. Two groups of plants or animals, originally identical, grow unlike one another when they are kept apart. The English pronunciation of Greek derived from Greek refugees, was gradually so much forgotten that Greek, as spoken by Englishmen, grew unintelligible to foreigners. It was evidently assimilating itself to English speech. 2. Two young Cambridge professors who had not learnt the language from Greeks—Smith and Cheke—deliberately set themselves to introduce a new style of pronunciation, suggested by Erasmus, modelled on English as it was then spoken. 3. They began by innovating timidly. Only now and then did they let drop words according to the new method, as if by accident. Day by day they increased the number of words thus modified. When the innovation was detected, they owned their design and communicated their plan to the younger men, who gladly adopted the new way. 4. Then the battle commenced. The dons protested, and the Chancellor intervened. He issued a succession of decrees, commanding the old way to be retained and the new abandoned. Compulsion stimulated opposition, but on the whole, and with relapses, the old prevailed. 5. The issues were complicated by the identification of the old method with Catholicism and the new with Protestantism, and the fortunes of the struggle waxed and waned with the fortunes of the ecclesiastical struggle. English Greek throve under Edward VI., and fell back when Mary came to the throne. It was finally triumphant only with the triumph of Protestantism under Elizabeth. 6. The underlying operative cause of the change was the greater ease in teaching and learning the new way. Pupils learnt more in a year by the new than in two by the old. 7. Auxiliary agencies co-operated. The popularity of Cheke and the influence of the Professor of Theology at Cambridge smoothed the path.

Here was illustrated the struggle for existence in all its forms. The new species or variety was sown or planted by foreign agency, or else a variety that was springing up of itself was cross-fertilised by a foreign element. It was slowly and gradually introduced, battling with the variety already in possession of the ground. The battle was not fought out on its merits: the issue was not determined by the rightness of the one or the other mode. The result was governed (1) by the superior ease of the acquisition—namely, by its fitness to the environment; (2) by the identification of the new struggle with a greater one—that of Protestantism; (3) by the popularity of its introducers and the authority (disguised force) of its supporters. Lastly, the new variety was represented by new individuals, not modified old individuals; it was the young professors who taught, and the undergraduates who accepted, the innovation. The old mode simply died out with the individuals who practised it. One generation was consumed in the process.

Among Dialects.

The struggle among inflections might be illustrated by exhibiting the conflict that took place between the immigrant plural and the dual, which, in at least the majority of known languages, was originally in exclusive possession of the ground. How imperfect was the victory of the invader is shown by the fact that, in the richest of ancient languages, the dual long held a place by the side of the plural. There was likewise a struggle among the various ways of forming the plural. In Old English six distinct species of plural fought for superiority. All but one have disappeared, though individuals have survived.

At the end of the tenth century four chief dialects were used in the north of France, each with its literature, and all with equal claims to predominance. In less than three centuries the dialect of the Isle of France supplanted Picard, Burgundian, and Norman, and became the French language. It followed the conquests of the Duke of France. Thus, in 1203, the Duke (become the King) of France annexed Picardy, and "drove out" (historians tell us) the Picard dialect. The driving out consisted in Picard ceasing to be spoken. French was first introduced into official acts, and became the preferred language of officials, many of whom were doubtless exported from Paris. It was taught in schools. Picard books next, and very gradually, were written in French. *Pari passu,* it was adopted in writing, or on ceremonial occasions by all who wished to be considered educated, even if they often spoke their native dialect when in their "shirt sleeves," as Cardinal Newman would have said. The populace stuck to the speech that most of them had never unlearnt, and it became a *patois,* or a merely spoken tongue. The two forms long co-existed, as English and its various dialects have long lived side by side. A Burns will write his elegiacs in English, his songs in Scots, and his odes in a mongrel dialect, half Scots and half English. A Carlyle, even in London, will cling to his northern Doric. So an Edward Fitzgerald, in full nineteenth century, may have a dialect "equal to Nithsdale." These are the unconquered survivors of a victory that was won by force in part, and by force masked as authority, but also in good part by the at length voluntary surrender of the beaten side.

Among Languages.

The linguistic struggle has been complicated and incessant in most European countries, where many races have been in conflict. Three or four languages strove for mastery in ancient Gaul. German was spoken by the 12,000 Frank invaders. Popular Latin was spoken by six million Gallo-Romans. Literary Latin was the language of the church and of literature. And Low Latin was afterwards the language of administration. German was the first to succumb. In four centuries it ceased to be understood by the soldiers, and in seventy years more it had become an object of ridicule. But it survives in more than 900 words, expressing the things of government, law, and war, and thus forms no insignificant part of the French language. The battle between Literary and Popular Latin had more varying fortunes. In the second century High Latin was in the ascendant; it was the dialect of the governing and educated classes. Two centuries later it had lost its ascendancy. The classes that spoke it were being extinguished by the decline of the Empire. Popular Latin gained the upper hand. There was no battle, but the masses that spoke the vulgar tongue were found everywhere, while the handful of nobles who spoke the literary dialect disappeared day by day, and, after the German invasions, they must have lost all

influence. The conversion of Popular Latin and not Literary Latin into literary as well as spoken French was a consequence of this defeat, which had its parallels in Spain and Italy.

The conflict continues everywhere in our own days. Thus French is driving back all but one of the languages spoken on its frontiers. It kills Celtic in Brittany, various Languedocian dialects in the south, Flemish in the Department of the North and in Belgium, and German in Switzerland. In the Southern Tyrol Germanic dialects are retreating before Italian. In Posen, on the other hand, Polish yields to German, but the islets of German speech in Bohemia melt into Czech. In Transylvania Magyar recoils before Roumanian; in Bukovina Roumanian recoils before Little Russian. On the banks of the Volga the Ural-Altaic languages disappear before Russian. At all these points, and at a thousand others, the struggle is never for a moment intermitted. The census records its vicissitudes. The diminished numbers of the speakers of a language is that of its dead. Finally it survives only in remote or isolated spots—in the mountains of Kentucky or Tennessee, in the wilder districts of Ireland, in those parts of the Scottish Highlands off the tourist beat, in the Faroe Islands, or wherever nature or a stationary state of society prevents the immigration of new species.

Languages owe their survival or their conquests to a variety of causes. No more than races, or than other sociological species, or than biological species, do languages flourish and survive on their merits. Not the intrinsic superiority of a language, its flexibility, or smoothness, or strength, or the wealth of its vocabulary, or the perfection of its inflections, gives it the victory in its struggle with rivals, or at least not these alone. Attic was not stronger than Doric, or the dialect of Wessex than that of Northumbria, or Erse than the Norse of the invaders of the west coast of Scotland.

Force incarnated as political ascendancy plays a large part. It may act indirectly. The Roman Conquest made Greek, and not Latin, the literary, judicial, and commercial language of the Orient. But it is more commonly direct. Through conquest Latin drove Greek from Magna Græcia or Southern Italy, Sicily, and Marseilles, and killed the indigenous languages in most Western countries. So did the Aryan invaders impose their language on the peoples of India, Greece, and Italy. Yet the conquering Teutons adopted the languages they found in Gaul, Spain, and Italy; the conquering Normans those first of Normandy and then of England.

Numbers are force, and the victorious language is often that of the more numerous race, but it is sometimes that of the less numerous; the Burgundians are shown by skull-measurements of the existing population to have been more numerous than the indigenous population, yet they adopted the Latin language. The conquering Arabs and Turks must have been far less numerous than the North Africans and the natives of Asia Minor.

Some point of advantage, extrinsic to the language, may endow it with superiority. Its fitness for the uses of commerce enabled Aramaic to overcome Hebrew, Assyrian, and Babylonian. The prestige of French conquests made French the language of diplomacy. The world-wide commerce of England has made English a world-wide language.

Yet in most cases it seems to have been the superior language that has prevailed. The Aryan languages have almost everywhere extirpated not only the Turanian, but also the highly-organized Semitic languages. Owing to the wealth of its vocabulary, its harmony, and its flexibility, Hindustani, a language born in the camp of the Grand Mogul, has supplanted several Indian tongues, and is now spoken by fifty millions. Perhaps a single notable example records the victory of the inferior language. Arabic superseded Greek and Latin in Syria, Egypt, and North Africa. The defeat of the higher dialects was an inevitable consequence of the defeat of the higher civilization.

A century hence, we may imagine, all other struggles over or reduced to insignificance, four world-languages will enter on an unending strife. A new and straightforward German will lord it over Central Europe. Imperial English will reign alone over the North American continent, and a more business-like Spanish will dominate its South American sister. While Russian, or some other rich Slavonian dialect, will blend the races of Eastern Europe and Central Asia into a harmonious federation.

"MAN'S PLACE IN THE UNIVERSE."*

By E. WALTER MAUNDER, F.R.A.S.

DR. WALLACE has not been long in fulfilling his promise to supplement his articles on the above subject in the March and September numbers of the *Fortnightly Review* with a fuller exposition of his views in book form. Appearing so soon after the discussion to which the first of those essays gave rise, the public interest has not had time to subside, and the book ought, and beyond doubt will, attain an exceptionally wide circulation. Should this be the case, as we trust it will be, the success of the book will be due to the extraordinary energy and promptitude of its venerable author. For an octogenarian to have produced, in barely half a year, so large a volume dealing with so wide a range of intricate subjects, and involving so large an amount of reading and reference, is in itself a remarkable achievement.

Dr. Wallace's great object is to prove,—or, at any rate, to show that it is exceedingly probable,—that this earth upon which we live is the only inhabited world in the universe. For this purpose it is necessary to bring forward some form of reasoning which shall not only show that our earth is the only planet within the solar system capable of sustaining life, but—a far more difficult proposition—to show that no sun other than our own could have a life-bearing planet amongst its attendants. From the nature of the case we cannot see a single planet of any star whatsoever, not even as a mathematical point of light. The only mode, therefore, by which the necessary argument can be constructed is by bringing out some point of difference between our sun and all other suns. If the system, of which it is the centre and luminary, is the only one in which intelligent life has a place, then it is indeed special, peculiar, unique. And if—and this is Dr. Wallace's fundamental assumption—this speciality of our sun is the necessary outcome of its physical properties and conditions, then these must be wholly and entirely different in some most important characteristics from those of any other of the untold millions of stars.

The problem, therefore, is, in effect, "Is our sun unique amongst the stars?" "Have we been able to detect any difference between it and all the host of its brethren?" And, if so, "Is this difference one which would affect the suitability of its planetary cortège for the origin and maintenance of life?"

Dr. Wallace's answer to these questions, as given in his first paper in the March number of the *Fortnightly Review*, was that our sun does differ from all others. It differs in position. It is in the very centre of the universe, and nowhere else than in that centre could life have been maintained sufficiently long to develop intelligence. He claimed that the whole trend of modern astronomical

* "Man's Place in the Universe: A Study of the Results of Scientific Research in Relation to the Unity or Plurality of Worlds." By Alfred R. Wallace, LL.D., D.C.L., F.R.S., etc. (Chapman & Hall.) 12s. 6d. net.

discovery tended to reverse the Copernican view of the earth, if we may use that expression, and to restore the Ptolemaic, that our solar system, in which this earth is by far the most favoured planet, was the central system of the entire sidereal universe; central not merely as to position in space, but in fundamental importance. "We ourselves are" the "sole and sufficient result," the "adequate reason why such an universe should have been called into existence." And "nowhere else than near the central position in the universe which we occupy could that result have been attained."

These are strong and far-reaching expressions, and oblige us to interpret Dr. Wallace's description of the sun as occupying the centre of the sidereal universe with a greater rigidity than he cared to admit. But we must bear in mind that the whole point, to demonstrate which he has directed his energies, is this: that there neither is, nor can be, any other inhabited world beside our own. "We ourselves are the sole and sufficient" cause why the universe has "been called into existence." And in his first paper the one physical condition upon which he relied to establish the improbability of life arising elsewhere than here, was the position of our sun in the centre of a cluster of suns, and that cluster situated, not only precisely in the plane of the Galaxy, but also centrally in that plane. If there was another sun that was nearer to that centre than we were, or even substantially as near, his argument, such as it was, was vitiated in its essential condition. No expression, therefore, however rigid and precise, could have so inexorably bound him down to the idea that our system was exactly and permanently central, as the exigencies of his argument did. This was a position which it was not possible for astronomers to allow to pass unchallenged. It was not warranted by the course of astronomical discovery, and if it should be widely accepted, it would tend to hamper our progress in the future. The immense problem of the true form and structure of the sidereal system—a problem in which a progress has been made of late years, which Dr. Wallace has either overlooked or ignored—will only yield, so far as its solution is possible, very slowly and gradually to patient, painful and continuous research. But if we are to assume at the outset that we occupy the exact centre of that universe, and invest that assumption with a quasi-theological authority, we shall have conjured ourselves back some three centuries or more into the position held by those who resisted and oppressed Galileo, and free enquiry into the greatest of physical problems will have come to an end.

The criticism offered by astronomers has had a good effect upon Dr. Wallace's book. It has induced him to give up the attempt to establish the unique character of our sun on the lines of a supposed central position. In his article in the *Fortnightly Review* for September he withdrew most of the advantages which he had suggested might accrue to our system from that position. In his book he gives up the position itself. He no longer plants the sun in the centre of the hypothetical solar cluster, but near its circumference (p. 304). He no longer places the sun in the exact geometrical centre of the Milky Way, but about one-twelfth of the diameter of the ring to one side (p. 162). He admits implicitly that many other stars are as well or perhaps better situated, and suggests that the advantage of the central position which they all thus share is that, being far within the circuit of the Milky Way, they may possibly be protected by it from certain supposed emanations. Now, just as it was necessary to lodge a protest when Dr. Wallace claimed for the sun a central position that was absolutely unique, so now there can be as little hesitation in declaring that he has at last read rightly his authorities—Sir John Herschel, Sir Norman Lockyer, and others. It is true in this very loose sense that the sun is central in the central plane of the Milky Way. It was most emphatically not true in the sense in which Dr. Wallace first used it.

The differentiation between our sun and other stars is now sought to be brought about in a much more legitimate way. He gives just prominence to Mr. Herbert Spencer's remarkable essay on the nebular hypothesis. It is true that the trend of more recent discovery has tended to weaken rather than support Spencer's argument. He could not write to-day "scarcely any nebulæ lie near the Galactic circle," but still the immense probability remains that the vast majority of all the celestial objects which we see are members of but a single structure. Whether we are acquainted with any aliens, and, if so, what proportion they form of the entire celestial host, we are not at present able to decide. Broadly speaking, stars, nebulæ and Galaxy, may reasonably be regarded as portions of one and the same building.

His next step is to point out that stars differ in their spectra; consequently our sun is marked off from all stars not of its own type. Further, even amongst stars of the solar type, there may be points of difference, and Dr. Wallace lays great stress on the discovery of spectroscopic binaries, already numerous, and quotes Prof. Campbell who believes that "the star that is not a spectroscopic binary will prove to be the rare exception." For both these statements Dr. Wallace has full and ample authority. Nay, more, it is highly probable that we need not stop here, but that, as our knowledge increases, we may find that no two stars are exactly alike, that each has some characteristic special to itself, some mark of individuality. But the inference which Dr. Wallace would draw is certainly unwarrantable, that all these differences necessarily imply unsuitability for life-bearing planets. On the contrary, since he accepts Sir Norman Lockyer's view that spectrum type means simply the factors of time and temperature, we are, on this hypothesis, in a position to assert with confidence that solar stars have existed in a stable condition, like our own sun, for a sufficient length of time for intelligent life to have developed somewhere within their attendant system. To reason otherwise is to beg nakedly the very question which it is desired to prove. And in effect this is all that his present argument comes to. Though it is a great improvement on the original argument, yet when the crucial step has to be taken from the ascertained facts to the wished-for conclusion, it amounts simply to assuming the very thing that has to be proved.

This is the point where the great argument of the book fails. In other parts it is much more successful. In chapters X., XI., XII., and XIII., where Dr. Wallace is dealing with the "Essential Characters of a living Organism," with "Essential life Conditions," and with "The Earth in its Relation to Life," he is treating of subjects upon which we have direct experimental knowledge, and many of which he has made largely his own. Here it is possible to follow him with much of both admiration and assent. And in chapter XIV., in which he claims to prove that "The Earth is the only habitable Planet of the Solar System," applying the lessons which he has drawn in the four preceding chapters, his argument is a strong one. Astronomers who have suffered much of late from having such absurdities fathered on them as the theory that the "canals" on Mars are evidence of the presence there of skilled engineers, and that the white spots occasionally seen on its terminator are the signals by which they are endeavouring to communicate with us, will welcome the clearness with which he has treated this part of his subject. I am personally exceedingly glad to see that Dr. Wallace argues that we have no real reason

for supposing "that the moon was once inhabited, and that Jupiter will be inhabited in some remote future." This has always been my own opinion, and I think that his method of treating this particular question is very forcible Up to the present time geologists have been disposed to claim a much longer duration for the maintenance of the present solar radiation than astronomers have been inclined to allow. Without endeavouring to adjust this difference between the two sciences, the inference is but reasonable and fair that no planet in the system differing very greatly in size from our earth, and therefore differing greatly from it in rate of cooling, could have passed through the same geological and biological epochs. There are two small points in this chapter which are stated too positively; these are: "The small size and mass of Mars being such that it cannot retain aqueous vapour; and the fact that Venus rotates on its axis in the same time as it takes to revolve round the sun." These two statements ought not to have been made without some caution to the reader that these "stated facts . . . . are by no means demonstrated, because founded upon assumptions which may be quite erroneous."

The promptitude with which the book has been brought out has had its drawbacks, for there are several indications of undue haste. Some of these are misprints, as "W. W. Turner," on page 142, for "H. H. Turner," and "Barnham" for "Burnham" on page 123, and again in the index. Some seem to be due to misapprehension of the authorities quoted, or more probably to carelessness in expression due to hasty writing. Thus, for example, on pages 59 and 60, our author says that to the naked eye no extensive region of the heavens is very conspicuously deficient or superior in the number of the stars which it displays; on page 123, that all the variable stars are to be found among the spectroscopic binaries; and on page 106, that "sunspots are of such enormous size that, when present, they can easily be seen with the naked eye," as if this were always the case. More curious are his inconsistencies. On pages 91–93 he gives a brief account of the determination of the sun's movement through space. This is in one of the first six chapters written specially "for the general educated body of readers," . . . . who are not "fairly acquainted with modern astronomical literature." He states there that the motion of the sun is probably about 12½ miles a second. Later on, in chapter VIII., he devotes some pages to showing that Prof. Turner and myself "made demonstrably baseless statements," when we simply called attention to this very solar motion. On page 143 he objects to my quoting Sir Robert Ball on the existence of dark stars, but on page 172 he quotes an exactly parallel passage from Sir Robert Ball to support himself when he finds it convenient to assume that dark stars are immensely numerous. On page 50 he quotes Sir John Herschel's description of the Milky Way "because he, of all the astronomers of the last century, had studied it most thoroughly." On page 162 he contemptuously puts on one side Sir John Herschel's remark "that the greater brightness of the southern Milky Way conveys strongly the impression of greater proximity"; this on the ground of a feature of the beautiful charts by the late Mr. Sidney Waters. It escaped Dr. Wallace's notice that the feature in question was a necessary result of the projection employed. Whilst it surely was a great mistake to argue as if the Milky Way shone in the same manner as an illuminated surface (*see* page 162). These are but a few of many similar oversights or inconsistencies.

Still, with all its drawbacks, the book is a wonderful one to have been produced in so short a time by a man who has devoted his fourscore years to a science which is not the one which forms the major part of the book. With all its want of precision, it is full of interest and charm, especially when we come to the chapters dealing with the biological side of the question.

Upon that question as a whole—the question whether life-bearing planets can exist in other solar systems than our own—the answer of science is clear and distinct. It is precisely the same which Prof. Newcomb recently gave concerning the possible inhabitants of Mars: "The reader knows just as much of the subject as I do, and that is nothing at all." Within our solar system we can indeed form some crude estimate of probabilities; beyond it, nothing. All the amazing progress of modern science, all the revelations made by the spectroscope or by photography, all the advance in biology, have not brought us one step nearer an answer to the question, "Is this the only inhabited world?" We stand essentially where Whewell and Brewster did half a century ago; or we might, indeed, say where Galileo and Capoano were three hundred years ago. We can, indeed, spin out the discussion at greater length than our predecessors, and can introduce a far larger number of more or less irrelevant facts, but of serious argument, either for or against, we are entirely destitute.

THE MARKINGS AND ROTATION PERIOD OF SATURN.

By W. F. Denning, F.R.A.S.

The conspicuous markings observed in the northern hemisphere of Saturn during the present opposition have greatly encouraged observation of, and interest in, a beautiful object. The complaint has sometimes been made that this planet, though forming an unique picture, attractive in the highest degree, yet lacks variety and the evidence of similarly great and abundant changes which render the study of Jupiter so entertaining. But the aspect of Saturn during the past summer has led to a modification of opinion on this point, and has proved that "the ringed orb" is occasionally the scene of extensive disturbances, and that the vapours surrounding him are travelling in parallel currents, differing in their relative velocities even more widely than those on the surface of Jupiter. In future years it is fair to assume, therefore, that Saturn will be more closely studied than hitherto. Apparently he has been somewhat neglected in the past; his ring-system has usually occupied chief notice, and perhaps diverted attention from more important phenomena displayed on the ball. In viewing this planet the observer's principal aim has been to obtain glimpses of the crape ring, Encke's division in the outer ring, or certain of the satellites, and thus the configuration in detail of the globe has escaped critical survey.

Astronomical records furnish comparatively few instances of irregular markings on Saturn, and when objects of this kind have been detected they do not appear to have always been followed with the necessary persistency. Sir W. Herschel was the first to discover evidences of rotation, and to determine a value for it. He narrowly watched certain inequalities in a quintuple belt, visible in the planet's southern hemisphere in 1793, December, and 1794, January, and wrote in the *Philosophical Transactions* for the latter year, "I can at present announce the reality of the quick rotation by means of 154 revolutions of the planet," and "We may conclude that the period is exact to ± 2 min., and we need not hesitate to fix the rotation of Saturn upon its axis as 10h. 16m. 0·44s."

Schroeter, of Lilienthal, made many observations of this planet more than a century ago, and derived rotation

periods of 11h. 40m. 30s., 11h. 51m., and rather more than 12h., from various markings he followed, but these results are very doubtful, and astronomers have never attached any weight to them.

Schwabe, of Dessau, observed markings in 1847, and a round bright spot near the S. limb was noticed by Busch and Luther in 1848. Certain dark patches were seen by Bond in 1848 and 1854, and re-observed by De la Rue in 1856. Lassell, Jacob, Coolidge, Dawes, Secchi, and a few others also detected spots at about the same period.

Lassell wrote in 1857, January 8: "There are certainly chronic changes of great magnitude occasionally occurring on the face of this planet."

Dawes stated* in 1858, January: "I have observed a well-marked light spot in the S. hemisphere of Saturn which I estimated to be at about 40° or 50° of S. latitude. It was nearly in the axial line on January 11, at 10h. 30m. G.M.T., and again on January 14, 11h. 20m., on both occasions a little past it."

Lassell viewed Saturn with a magnificently defined image in his 20-feet reflector of 20 inches aperture, powers 430 and 650, on 1858, April 17, just before 9 p.m., and said,† "Near the preceding limb, and a little south of the equatorial dark belt, was a brighter portion, too large to be called a spot yet sufficiently defined or marked out to be useful in determining the rotation of the planet."

The white spot seen by Dawes on 1858, January 11 and 14, and that observed by Lassell on April 17 of the same year, were probably identical objects, with a rotation period of nearly 10h. 25m. Dawes' two observations sufficiently prove that the marking exhibited a rate not differing greatly from 10h. 24⅓m.

Prof. Asaph Hall attentively studied Saturn during the fourteen years from 1875 to 1889 with the great Washington refractor of 26 inches aperture by Alvan Clark, and found that the ball of the planet presented very few changes, the most remarkable being the outbreak of an equatorial white spot, first seen on 1876, December 7. Prof. Hall said that "on poor nights when the image is blazing and unsteady we can see and can imagine many strange things about this wonderful object." The white spot was watched from 1876, December 7, to 1877, January 2, by Profs. Hall and Eastman at Washington, by Mr. A. G. Clark at Cambridgeport, and was also seen by several other American observers. A number of transits were secured, and from these it appeared that at intervals of three days the spot arrived at the planet's central meridian 16 minutes earlier than before. Prof. Hall found for the time of rotation 10h. 14m. 23·8s., with a probable error of only 2·3 secs.‡

In 1891 and three following years a considerable number of bright and dark spots near the equator and in certain other latitudes of Saturn were discerned by Mr. A. S. Williams, of Brighton, with a 6½-inch reflector. The results were discussed and summarised in *Monthly Notices*, LIV., p. 298—314, and LV., p. 354–67.§ The rates of the various objects differed slightly, ranging between about 10h. 13m. and 10h. 16s., but they appeared to present a satisfactory agreement with the earlier values of Herschel and Hall. It is only fair to mention, however, that several other experienced observers ‖ employing powerful telescopes quite failed to see any spots on Saturn at about the same period. It is not, however, our intention to discuss the question whether planetary markings can be easily seen in a 6½-inch telescope, and their individual forms traced while instruments of 36 inches and less fail to show any vestige of such objects. The remarkable efficacy of small telescopes in revealing planetary detail has often been admitted, but comparisons at the observatories of Mount Hamilton, Princeton, Chicago, and elsewhere have proved the undoubted superiority of large instruments.

In 1896 and 1897, M. Antoniadi, using the 9¾-inch refractor of the Juvisy Observatory, observed dusky condensations on the north equatorial belt, and from these he ascertained the rotation period as a little more than 10h. 14m.

During the last quarter of a century Prof. Hall's determination has been regarded as a standard value for the rotation of Saturn. True it was based on few observations extending over twenty-seven nights only, and upon an object obviously variable, for while at first it was round and 2 or 3 seconds of arc in diameter, it resolved itself at last into a bright streak.

The planet has been traversing the southern signs of Scorpio and Capricornus during the last few years, and its low position in the sky has had the usual effect in impairing the definition so much that observers in northern

Saturn, 1903, August 21, 11h.

latitudes have not been successful in detecting any irregular markings on the disc. The present opposition has, however, provided developments of very important and interesting character. Prof. Barnard was examining Saturn on June 15, 21h., G.M.T., with the 40-inch Yerkes refractor, when he discovered a decidedly marked white spot halfway between the central meridian of the planet and the following limb. Clouds came over, but the marking was recovered on June 23rd, when its passage across the central meridian occurred at 21h. 42m., G.M.T. It was seen again on June 24th, and the central transit observed at 18h. 58m., G.M.T. On July 1st the writer, at Bristol (unaware of previous observations), noticed a bright spot on Saturn which must have been central at about 14h. 1m., though it had passed to some distance west of the central meridian when first seen. This object was subsequently assumed to be identical with Barnard's spot of June 23rd, for eighteen rotations of 10h. 14½m. would accord well with the interval elapsed between the pair of transits, but further observations disclosed the surprising fact that the new markings were moving far too slowly to be consistent with the usually accepted rate of Saturn's rotation. Graff, of Hamburg, pointed out in *Ast. Nach.* that the period of Barnard's spot, deduced from a few of the earlier observations, was about 10h 39·01m., while Solà, of Barcelona, from more materials, found the value 10h. 38·4m. There have been several spots visible, both

* *Monthly Notices*, XVIII., p. 72.

† *Ibid.*, XVIII., p. 231.

‡ *Astronomische Nachrichten*, No. 2116.

§ *See* also *Ast. Nach.*, No. 3051.

‖ Prof. Barnard, writing in 1903, June, says that during all the observations he had previously made of Saturn he had never seen any marking that could be used for determining the rotation period.

light and dark, and the chief one, first seen at the middle of June, has been watched at Bristol during the past five months, and its mean rotation period has been as nearly as possible 10h. 38m. There is indication that the motion of this particular object has been slightly accelerated, but the evidence is not conclusive on the point. The other markings distributed along the same latitude show slight differences of period, and at the end of September they had become difficult objects.

In June the principal spot was large, and very much brighter than the light north-temperate zone in which it was placed. The usual observational discordances have become apparent as regards the transit times, the form, dimensions, and aspect of the marking. Barnard on June 23 found the length, E. and W., 2″·6. H. C. Wilson, at Northfield, Minn., on July 1 measured the length, 3″·93, and width, 2″·36, while Graff on June 26 gave the proportions 5″ by 3″. The spot is both followed and preceded by dusky patches stretching from the north equatorial belt to the polar shading. As seen by Wilson on July 1 it appeared surrounded by a narrow dark line, but the observer suggests that this may have been the effects of contrast. The north latitude of the spot, according to a measure by Barnard on June 23, was 36°·4, while Wilson determined it on July 1 as 31°·1.

Present indications are that the disturbance has, in its main features, practically subsided. Its lessons cannot fail to be of considerable interest. It has afforded the clearest proofs of a north-temperate current rotating $23\frac{1}{2}$ minutes slower than the equatorial current as determined by Prof. Hall from his spot of 1876-7. A comparison of the relative velocities leads us to the following curious deductions. The equatorial spots are moving so much faster than the north-temperate spots that they gain some 800 miles per hour upon them, and complete a circuit of Saturn relatively to their positions in about 12 days. A terrestrial hurricane is supposed to have an extreme velocity of about 100 miles per hour, but the wind currents on Saturn appear to be incomparably swifter. And the rapid equatorial drift on Saturn is probably persistent within small limits of variation like the equatorial current of Jupiter, which, during the last 25 years, has only varied between 9h. 50m. and 9h. $50\frac{1}{2}$m.

On the latter planet the ordinary north-temperate spots rotate in 9h. 55m. 54s., which is about $5\frac{1}{2}$ minutes slower than the equatorial spots. Both on Jupiter and Saturn, therefore, the mobile vapours on or near the equator are streaming along with abnormal velocity, outstripping other markings to N. and S., and also, probably, the actual rotatory movement of the immense spheres below. There may be occasional exceptions, it is true, as, for instance, the very rapidly moving dark spots which temporarily marked the north-temperate region of Jupiter in 1880 and 1891.

The closer scrutiny of Saturn in future years is desirable, and it seems well assured from the interest awakened by the prominent signs of activity recently displayed on the planet's surface. The investigation is a promising one. It may appear curious, on reflection, that comparatively little has been already accomplished in elucidating the visible surface phenomena of this wonderful orb, forming as he does the most charming picture in the sky. Perhaps Saturn has sometimes been regarded as an object more suitable for exhibition than for sedulous research. In any case it is to be hoped that he will now receive more fitting recognition, for his belts and occasional spots merit as much attention as the variegated scenery of Jupiter or the wonderful and complicated canaliform aspect of Mars.

Previous observations suggest that the rotation of the equator of Saturn is 10h. $14\frac{1}{2}$m., of the south-temperate region 10h. 25m., and of the north temperate region 10h. 38m. But the materials are altogether too scanty for safe deductions. Many new observations are required of well-marked equatorial and south-temperate spots. We may have to wait years for the apparition of these, for Saturn's aspect is often serene and smooth, without any obvious irregularities in the belts and zones.

Postscript, Nov. 15.—Including my latest observations here with a 10-inch reflector, powers 312 and 332, the mean rotation periods of three of the best observed spots on Saturn work out as follow:—

Object.	Interval of Observations. Days.	Rotations.	Period. h. m. s.
Barnard's White Spot	138	310	10 37 52·4
White Spot	132	295	10 37 42·0
Dark Spot	120	270	10 37 56·4

The period appears therefore to be a little less than 10h. 38m., and bears out the suggestion previously made that the velocity has been accelerated.

THE CHEMISTRY OF THE STARS.

VI.—STARS OF THE THIRD AND FOURTH TYPES.

By A. Fowler, F.R.A.S.

Secchi found that stars of a decidedly orange or red tint were generally distinguished spectroscopically by the presence of "flutings," and he further recognized that such stars were easily divisible into two groups. In one of them, constituting his Type III., there are dark flutings which degrade towards the red end of the spectrum, while in the other group, which he designated Type IV., the flutings fade off towards the violet. In both types the blue end of the spectrum is very feeble, probably in part through deficient continuous radiation, and partly on account of excessive absorption, and it is to this fact that the redness of the stars is to be attributed.

What is meant exactly by a fluting may be gathered from Fig. 11, illustrating the fluted spectrum of carbon, as exhibited in the spectrum of the electric arc between carbon poles. The spectrum consists of a number of groups of flutings, or shaded bands, each simple fluting commencing with a well-defined "head," and being followed by closely-ruled fine lines which gradually get feebler and further apart as the leader is left behind.

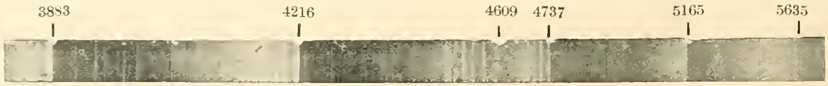


Fig. 11.—Flutings of Cyanogen and Carbon.

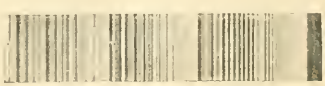


Fig. 12.—Enlarged View of Fluting λ 3883.

This structure is better seen in the enlarged view of one of the flutings given in Fig. 12. Here, the flutings fade to the violet, but in some cases the degradation is towards the red. Laboratory experience teaches that flutings only appear in the spectra of sources of light which are at a relatively low temperature as compared with that necessary for the production of the line spectra of the same substances; their presence is, therefore, a valuable clue to the temperature conditions which prevail in the atmospheres of the stars which exhibit them. Many flutings originate in compounds, those at $\lambda\lambda$ 3883, 4216, and 4609 in the arc spectrum of carbon, for example, being almost certainly due to cyanogen, and the disappearance of such flutings at increased temperature is sufficiently explained by the breaking up of the compound into its constituent elements. The replacement by lines of flutings of elementary substances, such as those of carbon at 4737, 5165, and 5635, may be supposed, as suggested by Lockyer, to be brought about by the separation of complex molecular groupings into simpler ones.

Extensive observations of the spectra of third and fourth type stars (or *Antarian* and *Piscian* stars, in Lockyer's nomenclature) have been made by Duner, Vogel, Huggins, Espin, and others, but visual observations, though of intense interest to the observers, are now quite superseded by photographs in all investigations involving accurate measurements. Many successful photographs of third type spectra have been secured at various observatories, and we are fortunate in having the kind permission of Father Sidgreaves to reproduce two beautiful examples from the Stonyhurst collection, illustrating the spectrum in the yellow, green, and blue. α Herculis may be considered a normal third type, while the photograph of Mira admirably illustrates the introduction of bright hydrogen lines which is, in some way, associated with the variability of that star, and is, in fact, characteristic of the numerous variables having spectra of the third type.

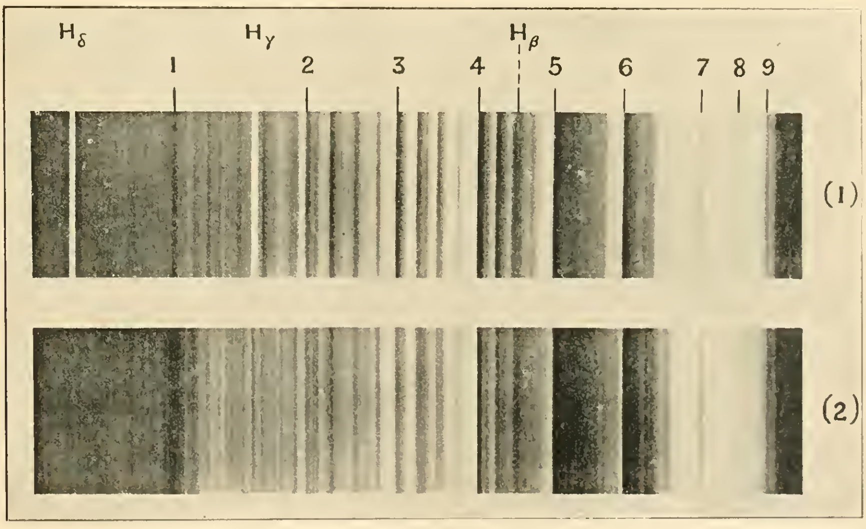


Fig. 13.—Spectra of o Ceti and α Herculis, from photographs taken at Stonyhurst College. The wave-lengths of the numbered lines and bands are:—(1) 4227, (2) 4420, (3) 4581, (4) 4757, (5) 4951, (6) 5165, (7) 5447, (8) 5597, (9) 5756.

On account of their feeble luminosity, none of them being brighter than 5th magnitude, the spectra of the fourth type stars can only be photographed with great

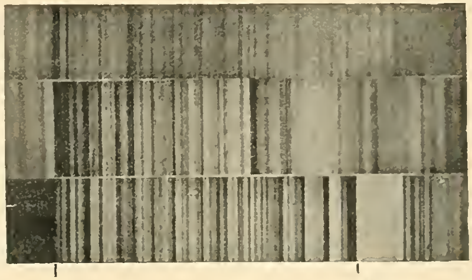


Fig. 14.—Spectra of (I.) Sun, (II.) μ Geminorum, (III.) 132 Schjellerup. From photographs taken at the Yerkes Observatory.

difficulty. McClean, however, succeeded in photographing two of the brightest specimens, and discovered that besides the flutings the spectra contain numerous lines which greatly resemble those of α Tauri. Unexpectedly fine photographs, exhibiting a wealth of detail, have since been obtained at the Yerkes Observatory, where the great light-gathering power of the 40-inch refractor has allowed the use of considerable dispersion. Through the kindness of Prof. Hale, we are able to reproduce the interesting series of photographs in Fig. 14, comparing the yellow and green parts of the spectrum of a third and a fourth type star with that of the sun.

The number of third type stars already known is estimated by Miss Clerke at about 2000, and that of the

fourth type at 250. Some of the more notable examples are indicated in the following table:—

TYPE III. (Antarian.)	TYPE IV. (Piscian.)
β Andromedæ.	51 Schj. (Mag. 6·0), R.A. 5h. 0·2m. Decl. + 1° 2′.
o and α Ceti.	74 Schj. (Mag. 6·5), R.A. 6h. 19·8m. Decl. + 14° 47′.
γ Hydri.	78 Schj. (Mag. 6·3), R.A. 6h. 29·7m. Decl. + 38° 32′.
α Orionis.	115 Schj. (Mag. 6·5), R.A. 8h. 49·8m. Decl. + 17° 37′.
η and μ Geminorum.	136 Schj. (Mag. 6·0), R.A. 10h. 46·8m. Dec. − 20° 43′.
γ Crucis.	152 Schj. (Mag. 5·5), R.A. 12h. 40·4m. Decl. + 45° 59′.
δ Virginis.	229 Schj. (Mag. 6·5), R.A. 19h. 25·1m. Decl. + 76° 22′.
δ Ophiuchi.	249A Schj. (Mag. 6·2), R.A. 21h. 37·8m. Decl. + 35° 3′.
α Scorpii.	19 Piscium (Mag. 6·2), R.A. 23h. 41·3m. Decl. + 2° 56′.
α Herculis.	
β Gruis.	
β Pegasi.	

Taking first the stars of the third type, it will be seen from the examples given that there is a well-marked line spectrum in addition to the flutings which form so conspicuous a feature of the visual spectrum. It was noted by Angström that the flutings resembled in a general way those which appear in the spectrum of manganese oxide, and Lockyer in 1888 suggested that they were probably to be accounted for chiefly by manganese, magnesium, and lead. These identifications, however, were based upon visual observations, and may need revision when more precise wave-length determinations have been made. Lockyer considers that some of the apparent bright flutings, such as that beginning at λ 5165, are real and probably due to carbon, but the difficulty in distinguishing between real flutings and interspaces is so great that a final decision will probably not be reached until a complete matching with some terrestrial spectrum is effected.

The interpretation of the line spectrum is also incomplete, but much more definite so far as it goes. Taking the lines generally, they bear a considerable resemblance to the solar lines, but most of them are very broad, and the relative intensities are so different as to greatly modify the appearance of the spectrum when compared with the sun. Lockyer, in 1893, announced the detection in Betelgeuse, the brightest member of the group, of lines due to hydrogen, iron, manganese, chromium, calcium, magnesium, cobalt, strontium, and lithium, and pointed out that the lines which appear at the comparatively low temperature of the oxy-hydrogen flame were especially strong. The blue line of calcium at λ 4227, for example, which is pre-eminently the low temperature line of this element, is very dark and distended in the photograph of α Herculis (Fig. 13). A recent investigation of the spectrum of Mira which has been made at the Lick Observatory indicates the presence of iron, vanadium, chromium, calcium, aluminium, and strontium, but manganese and titanium are considered doubtful. Still more recently, an investigation of χ Cygni made at Potsdam by Dr. Eberhard establishes the presence in that star of calcium, titanium, chromium, vanadium, iron, and magnesium. Hence, combining the different results, and including sodium from the very obvious D lines, we may take the following list as representing the elements so far identified in the third type stars:—

Aluminium.	Iron.	Sodium.
Calcium.	Lithium.	Strontium.
Chromium.	Magnesium.	Titanium.
Cobalt.	Manganese.	Vanadium.
Hydrogen.		

The identification of vanadium and titanium may possibly turn out to be of special significance, on account of the predominance of lines of these elements among the lines which are most widened in the spectra of sunspots. Dr. Scheiner has recorded that some of the stellar lines are shaded on one side in a manner which recalls the appearance of some of the lines in spot spectra, and it has been suggested that the greater part of the surface of a third type star may be in a condition corresponding with that of a solar spot. Attempts have also been made to account for the variability of so many of the third type stars by supposing a fluctuation of spotted area corresponding with the eleven-yearly period of the sun, but it is by no means clear why many of the stars exhibit no changes of magnitude in spite of their supposed spotted surfaces.

Passing next to the fourth type stars, we have already noted that the characteristic feature of the spectrum, in visual observations at least, is the presence of dark flutings fading off towards the violet; one lies in the yellow green and begins at λ 5635, one in the green near *b*, λ 5165, and the other in the blue just beyond F, λ 4737. Secchi's discovery that these were due to carbon vapour has received abundant confirmation, and besides these the Yerkes photographs show the violet and ultra-violet flutings of the cyanogen spectrum, beginning at λ 4609, 4216, and 3883. The *lines* recorded in these stars in visual observations do not number a dozen, and only sodium, iron, and hydrogen could be recognized. The new photographs, however, reveal the existence of hundreds of lines, and, thanks to advance proofs with which Prof. Hale has been good enough to furnish me, I am able to give the following list of elements which have now been identified in the fourth type stars:—

Calcium.	Iron.	Sodium.
Carbon.	Magnesium.	Titanium.
Chromium.	Manganese.	Vanadium.
Hydrogen.	Nickel.	And possibly others.

The representation of calcium by the blue line at λ 4227, which is of great strength, and by the H and K lines, is worthy of special mention, on account of the similar appearance of these important lines in stars of the third type.

Prof. Hale concludes that the carbon and metallic vapours are very dense and lie immediately over the photosphere, while above these rise other vapours or gases producing *bright* lines to the number of about 200, none of which have been identified with certainty. Though Prof. Hale seems to have convinced himself of the reality of these bright lines, it is by no means impossible that Lockyer may be right in considering them as mere effects of contrast.

It is interesting to find that the relatively low temperature which is suggested by the flutings in the fourth type stars is also indicated by the discussion of the line spectrum. Prof. Hale remarks that while arc and flame lines, such as the calcium line 4227 are of great strength, spark lines, such as that of titanium at 4534·14, are less prominent or entirely missing, and though he adds that this does not certainly prove that the temperature of the reversing layers of the fourth type stars is lower than in the case of the sun, the evidence is entirely in favour of this supposition.

It has been further ascertained that many of the lines which are widened in sunspots appear as strong dark lines, and the suggestion naturally is that spots similar to those which appear in the sun may be very numerous in stars of the fourth type, as has been previously suggested in the case of stars of the third type. The variability of so many stars of the fourth type is looked upon as favouring this supposition.

The place of the third and fourth type stars in the supposed evolutionary series has been the subject of much discussion. Vogel considers that after the solar stage is passed, a star develops into one of the third or one of the

fourth type according to the chemical combination which is first formed in its atmosphere (the bands described in the foregoing as carbon bands being attributed by some to hydrocarbon, and not to the element carbon), and Duner has adopted the same view. That the fourth type stars follow the second may be considered as fully established; for besides the evidence afforded by the line spectrum, there is in the solar spectrum a well-marked absorption fluting in the ultra-violet at λ 3883, corresponding with one of the flutings seen in the Yerkes photographs of the fourth type stars, and, according to Rowland, there are many faint solar lines which agree with the constituent members of the carbon fluting 5165.

It is the place of the third type stars which remains somewhat doubtful. They do not seem to come *between* the second and fourth types, and probably few would be inclined to place them after the fourth type, although the carbon and cyanogen flutings typical of the fourth type stars survive the temperature of the electric arc while flutings of other substances fail to do so.

Prof. Hale practically adopts Vogel's view, on the ground that the resemblances between third and fourth type stars are greater than the points of difference; they resemble each other, for instance, in colour, tendency to variability, spectra, possible presence of sun-spots, physical condition and probable relationship to solar stars, and "they should therefore be classed together as co-ordinate branches leading back to stars like the sun." The spectroscopic similarity of the two types, according to Prof. Hale, is intensified by the presence in both of the cyanogen flutings in the violet, beginning at λ 4609. Apart from the differences in the other flutings, the chief important divergence is in the distribution of the two types over the celestial sphere, the third type stars showing no preference for the region of the Milky Way, while the stars of the fourth type are distinctly condensed in this neighbourhood.

Assuming the third and fourth type stars to be alternative forms of decaying solar stars, the greater part of the story of stellar evolution, according to the views of Vogel and others, may be shortly expressed as follows:—

Type 0 (Orion stars).
Type I.
Type II.
Type III.—Type IV.
Dark stars.

There is good reason to believe that the maximum of cosmical temperature is manifested in the Orion stars, and it is possible that this stage is reached by the condensation of nebulæ through a stage represented by the Wolf-Rayet stars, the spectra of which chiefly consist of bright lines.

Lockyer finds a difficulty in believing different kinds of stars to represent a similar stage of development, and, as previously explained, divides the stars into *two* series, one supposed to include stars of increasing temperature, and the other the stars which are becoming cooler. Stars of the third type take a low position on the rising branch of his "temperature curve," following the nebulæ, and those of the fourth type end the series of luminous bodies on the descending branch. A general statement of Lockyer's classification, embodying this idea, is as follows:—

Highest Temperature.

Proto-hydrogen Stars	Argonian Alnitamian	
Helium Stars	Crucian	Achernian
	Taurian	Algolian.
Proto-metallic Stars	Rigelian	Markabian.
	Cygnian	Sirian.
	Polarian	Procyonian.
Metallic Stars	Aldebarian	Arcturian.
Stars with fluted spectra	Antarian	Piscian.

Lowest Temperature.

Notwithstanding the divergence of opinion on some points, there is a general acquiescence in the view that the matter composing the stars is essentially the same as that with which we are acquainted on the earth. This leading idea is admirably expressed by Sir William and Lady Huggins in the following passage in their "Atlas of Representative Stellar Spectra":—"As the conclusion of the whole matter, though there may be no reason to assume that the proportions of the different kinds of chemical matter are strictly the same in all stars, or that the roll of chemical elements is equally complete in every star, the evidence appears to be strong that the principal types of star-spectra should not be interpreted as produced by great original differences of chemical constitution, but rather as successive stages of an evolutional progress, bringing about such altered conditions of density, temperature, and mingling of stellar gases, as are sufficient presumably to account for the spectral differences observed, even though with our present knowledge a complete explanation may not be forthcoming."

Investigations are still in progress in many lands, and it is not too much to expect that sooner or later the story of celestial evolution will be completely elucidated.

THE SUNSPOTS OF 1903, OCTOBER.

By E. Walter Maunder, F.R.A.S.

In a few short months we have passed from a period of extreme quiet on the sun to a period in which great spots have begun to show themselves. I should wish to use this term of "great spot" in a strictly definite and limited sense. For in every sunspot cycle there are a few groups which stand out, beyond all others, by their pre-eminent size, the giants of their kind. "Normal" spots, to use Miss Brown's nomenclature, or "regular" spots, to use that of the Greenwich Results, that is to say spots nearly circular in shape and with umbra central and also nearly circular, generally have an area of from 100 to 300 millions of square miles. Above this size they generally show a much more irregular and complex structure, and at times of maximum activity, groups with a total area of 700—a million of square miles being taken as the unit—are pretty frequent. But the groups which attain a mean area of double this amount are few indeed. Only sixteen were recorded from the beginning of the Greenwich record right up to the end of September of the present year. And if we take a higher limit still, and fix an area of 2000 as the smallest for a really "great group," we shall find that that maximum is an unusual one that can boast of half-a-dozen members of the class. Necessarily, solar disturbances on this scale are strictly confined to the years of maximum activity, and the last two maxima only show five such groups between them.

The appearance at the east limb on October 4 of a regular spot, the first member of a group which was fully entitled to be classed amongst these giants, marks, therefore, an epoch of great interest in the progress of the present cycle. The interest in it is greater when we bear in mind that in previous cycles the increase in activity has followed so rapidly after the appearance of the first really great spot, that the largest group of the entire cycle has usually been registered within six or seven months afterwards. Spot groups continue to increase in frequency, indeed, for a considerably longer time, but, as a rule, not in size. If this precedent be followed, then the greatest single disturbance of the present maximum may be expected not later than April or May, 1904, whilst the actual summit of the curve is rather to be expected to fall in 1905, probably somewhat late in the year.

Nor has this great outburst come alone; two others, both of very considerable size, have accompanied it. The

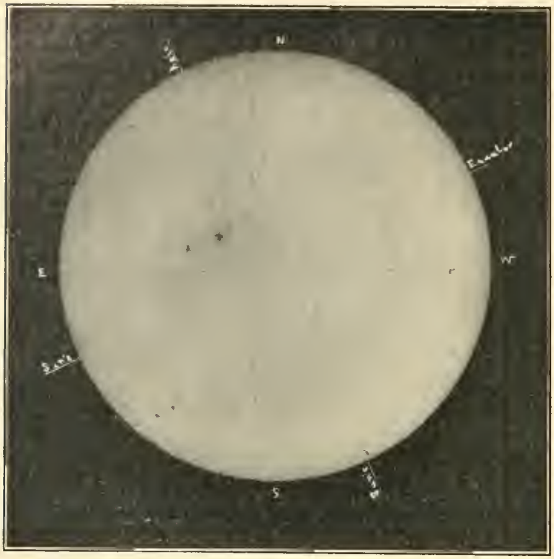


FIG. 1.—The Sun, 1903, November 4d. 12h. 21m. 20s.

first of these appeared at the east limb of the sun on October 2, its heliographic latitude being 18° North. For sake of clearness of reference I will call this the Northern Group. The second, the one to which I have already alluded, began to appear at the east limb on October 4, its latitude being 21° South, and I will refer to it in future as the Great Southern Group. The third, and smallest of the three, was in many ways the most interesting, inasmuch as its passage across the central meridian of the sun was synchronous with a magnetic storm of the very first order. I will therefore refer to this group as the Storm Group.

The Northern Group, at its first appearance, consisted essentially of a regular or normal spot, followed by a number of very small companions in a long stream. The area of the chief spot was about 270 millions of square miles, but when it had returned to the east limb on October 29 for its second apparition, it consisted chiefly of two large regular spots, and the total area of the two was fully 800 millions of square miles. It began to pass the central meridian about 4 o'clock on the morning of November 5, and had completely passed by 11 o'clock on the morning of November 6. At this time the area of the group amounted in the whole to 1100 millions of square miles; the two principal spots having areas of 650 and 310 respectively. A distinct, but quite minor oscillation of the magnets took place during the evening and night of November 5, that is to say, just when this group was in mid-transit. Fig. 1 shows this Northern Group approaching the central meridian.

The Great Southern Group was of quite another order. Like the Northern Group it formed in the unseen hemisphere, but its formation was preluded by the appearance of a short-lived spot from September 10 till September 16. This spot, however, died out before reaching the west limb, so the Great Southern Group was a new formation. It, therefore, was a young group when it was first seen on the east limb on October 4 and 5, and must have grown with extreme rapidity. At first it was practically a single huge spot of nearly 7° in greatest breadth, and about 15° in greatest length. But it was speedily intersected by an exceedingly beautiful and complex system of bright bridges which soon divided it up, and a broad bright region formed about the centre of the spot, making a wide gap between the preceding and following portions. Its total area on October 9 exceeded 2400 millions of square miles. The first member of the group reached the central meridian about October 10, 19 hours; the last spots crossed about October 12, 2 hours, civil time; and the group passed out of view at the west limb on October 17 and 18. Its second appearance at the east limb occurred on November 2, and on November 4, the day represented in Fig. 1, it was seen as a very long stream of spots, or rather as four distinct groups following each other at short intervals. It passed off at the west limb for the second time on November 14 and 15.

Shortly after this group had completely passed the central meridian (*see* Fig. 2), a very marked magnetic disturbance commenced. The movements of the needle began about October 12, 18

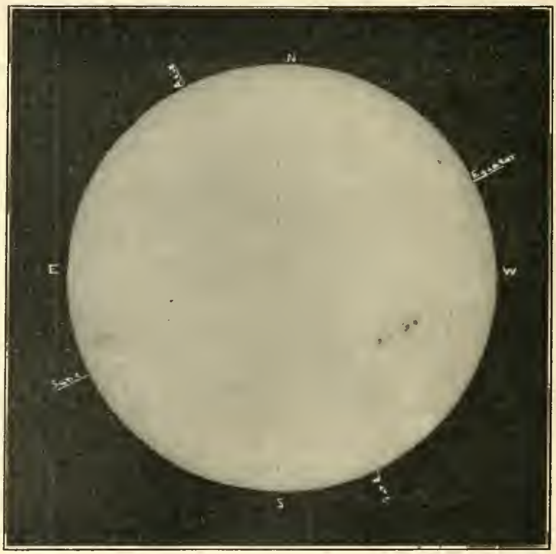
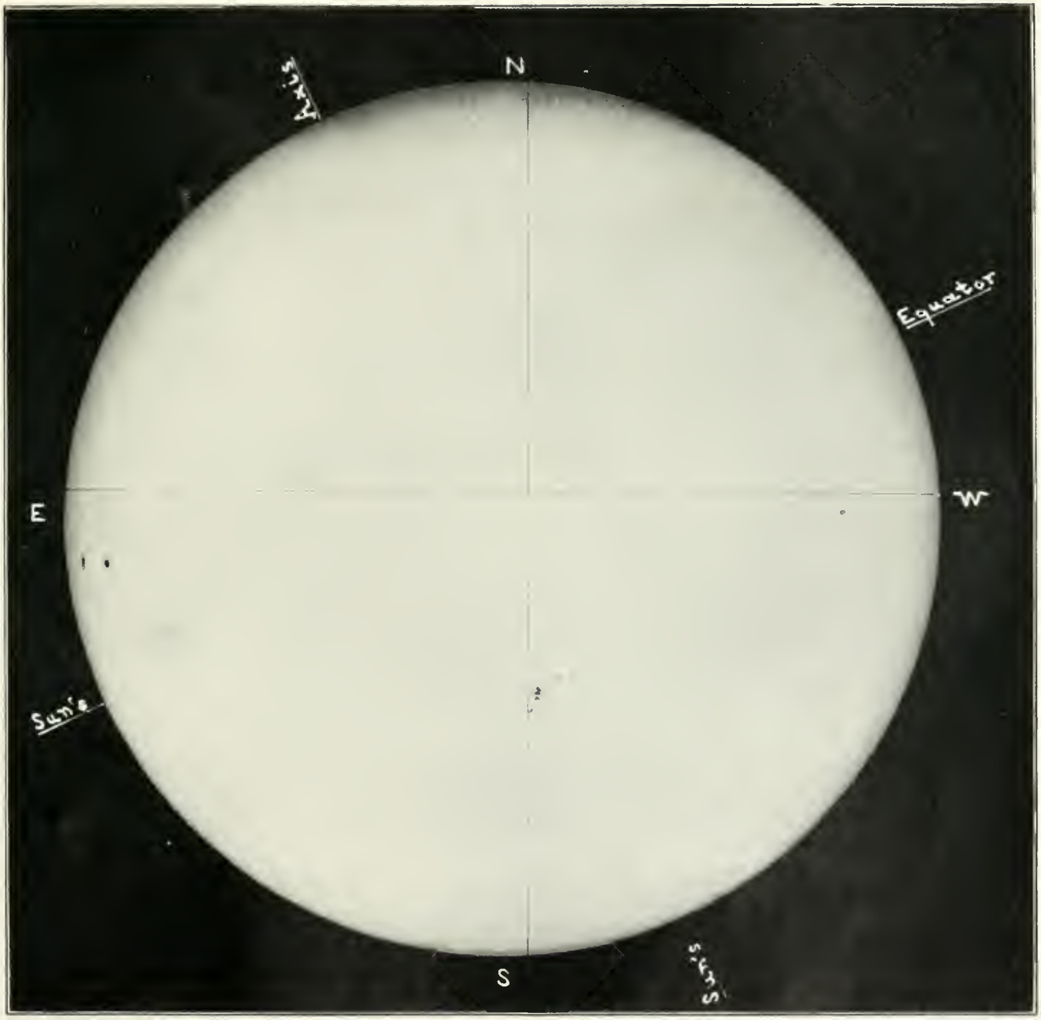


FIG. 2.—The Sun, 1903, October 12d. 11h. 36m. 49s.

hours, that is to say about 6 o'clock in the evening, and from 8 o'clock in the evening until about three in



PHOTOGRAPH OF THE SUN.

1903. October 31d. 10h. 24m. 28s., Greenwich Civil Time.

Taken at the Royal Observatory, Greenwich, with the Dallmeyer Photoheliograph. Aperture 4 inches; reduced to 2·9 inches.

the following morning, its oscillations were specially marked. After that they began to die away, and the disturbance ended about an hour later. This was by no means a magnetic storm of the first rank, but it was decidedly the most striking that had been recorded since 1898, September, and it may fairly be regarded as distinctly of the second class in importance. The greatest amplitude of movement in declination was 35′.

The third group, which I have called the Storm Group,

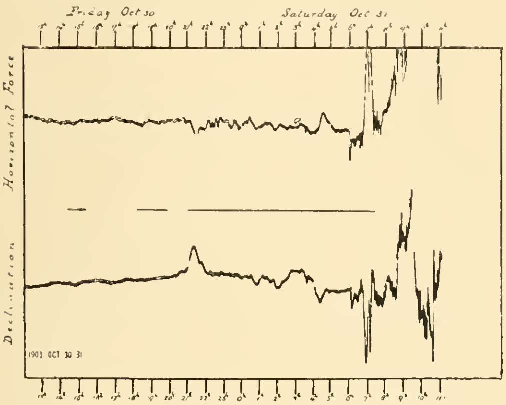


Fig. 3.—Greenwich Magnetic Register; Declination and Horizontal Force; 1903, October 30–31.

came on the sun at the east limb on October 25, and touched the central meridian at 10 o'clock in the morning of October 31, where it is shown on the Plate. It is seen on Fig. 1 near the west point. Its passage across the meridian took about eighteen hours, so that it had entirely passed by November 1, 4 hours. A little before it reached the meridian, an extraordinarily violent magnetic storm began. It commenced in the characteristic way, so often noticed, of a sudden sharp twitch of the needle, first slightly to the east, then strongly to the west, and back. At 13 hours the vibrations of the magnet became very violent, and from this time until 23 hours on October 31, changes in declination exceeding a degree in magnitude were frequent. By the kindness of the Astronomer Royal, to whom we are also indebted for permission to reproduce the solar photographs given in the text and in the Plate, we are enabled to give reduced copies of the Greenwich photographic registers of declination and horizontal force from noon, October 30, to noon, November 1. It will be seen that the spot of light thrown by the horizontal force magnet ran off the barrel continually, especially during the afternoon and evening of October 31, and that sometimes the registers for declination and horizontal force became inextricably confused together. The vertical force register showed aberrations as extreme during the height of the storm. The extreme range in declination was more than 2°, the most westerly position being registered October 31, 15 hrs. 40 min., the most easterly, October 31, 19 hrs. No storm so violent has been registered since that of 1882, November 17. The recent storm, however, was by no means so long enduring as the one of 1882 (*see* Figs. 3 and 4).

The earth current register from noon on October 31 is also given (Fig. 5). The Greenwich earth current registers are, in the ordinary way, completely spoiled by the blurring caused by the City and South London Electric Railway during the whole time that the cars are running on that line, and the genuine earth currents can only register themselves during the few hours of early morning when the railway is at rest. But the storm of October 31 was so violent that any effect from the City and South London Railway was entirely overpowered. The effect of the storm upon telegraphic communication the world over was most pronounced. During a part of October 31, France, for instance, was almost entirely isolated as regarded telegraphic communication; the lines to Central and South America failed first, those between Paris and the south of France next, and then the lines between Italy, Spain, Portugal, and Algeria. Similarly there was great interruption in telegraphic communication from London westward to New York, and eastward to northern Europe; and in the United States the great land cable lines were much affected, causing, in some localities, a total cessation of business. Fine auroræ were observed, not only in England, but also in the State of New York and in Hungary.

It seems to me that the appearance of these three groups of spots, and the occurrence of three distinct magnetic disturbances practically simultaneous with the passages of the spots across the central meridian of the sun's disc, is exceedingly instructive. On the one hand, it points unmistakably to a true connection between the two orders of phenomena; the spots on the sun, and the magnetic variations on the earth. Next, it shows most emphatically that it is not possible to take the area of the spot as a measure of the intensity of the magnetic storm. The three magnetic disturbances were altogether of different orders. The first, that of October 12 to 13, was a respectable example of the second order; but the spot with which it was associated was quite exceptional in size; entirely of the first rank. The second magnetic disturbance was not only one of the first class, but an exceptionally intense one of that class; the spot with which it was synchronous was large indeed but quite of the second

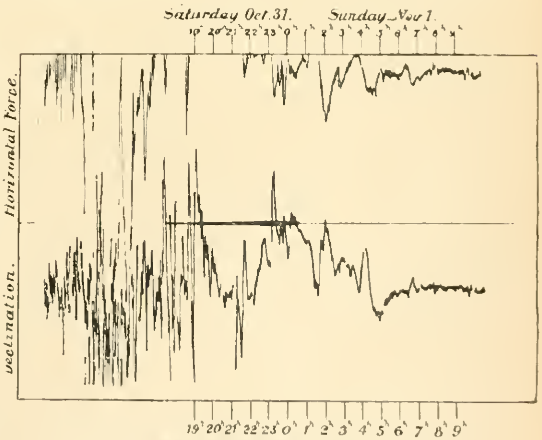


Fig. 4.—Greenwich Magnetic Register; Declination and Horizontal Force; 1903, October 31–November 1.

rank. The third magnetic disturbance, though distinct, was altogether insignificant in amount, one of the fourth or fifth rate; whilst the spot synchronous with it was decidedly larger than the one synchronous with the great magnetic storm. The question still remains which of two

hypotheses we are to choose in order to explain this quantitative discrepancy. On the one hand, it is very conceivable that though the sunspot is directly the cause of the terrestrial magnetic effect, it is not the size of the spot which is the determining factor so much as some other characteristic less easily recognized. Thus both the Storm Group of October 31 last, and the group of 1882, November 17, were distinguished by the number and vividness of the hydrogen reversals in their spectra, and it is

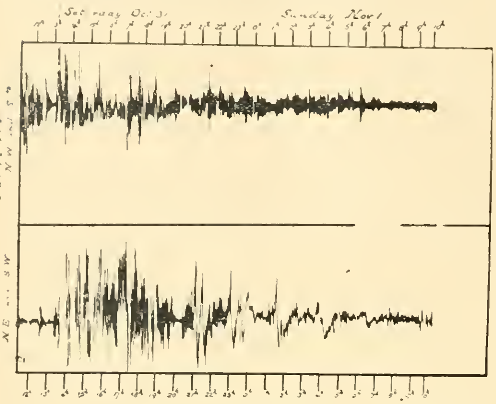


Fig. 5.—Greenwich Earth Current Register. 1903, October 31–November 1.

conceivable that such reversals may be significant of more effective action than the mere extent of surface of the group. On the other hand, it may be that the connection between sunspots and magnetic storms is not direct but indirect; both being the effects of some one common cause which, nevertheless, does not act upon sun and earth always in the same proportion. But, in any case, whether the connection be direct or indirect, whether it be immediate or only secondary, there can be no doubt that it is real, actual, and effective.

Letters.

[The Editors do not hold themselves responsible for the opinions or statements of correspondents.]

STELLAR SATELLITES.

TO THE EDITORS OF KNOWLEDGE.

Sirs,—With reference to Mr. Holmes' letter in the November number of Knowledge, there can be no doubt whatever as to the existence of the satellite to Procyon. It has been seen and measured by Barnard, Hussey, See and Lewis, as well as by Schaeberle. The following are some of the measures made since its discovery:—

	°	″	
1898·213	326·0	4·83	*Astronomical Journal*, 540, 541, June 18, 1903.
1899·073	330·6	4·91	
1900·055	336·0	5·09	
1902·241	346·5	5·11	Hussey (Lick Observatory *Bulletin*, No. 44).
1903·154	351·03	5·16	Barnard (*Astro. Journal*, June 18, 1903).

It has therefore moved about 25° in five years, or 5° per annum. It was also measured at Greenwich Observatory in 1902.

With reference to the double companion of Rigel, Burnham says (*Publications* of the Yerkes Observatory, Vol. I., 1900, p. 60), after describing his unsuccessful efforts to divide the small star, "Since the foregoing was written I have received the recent measures of Aitken and Hussey, made with the great refractor at Mount Hamilton. There is no longer any doubt of the duplicity of this star. It is equally certain that the period will be very short—perhaps shorter than that of any known system," and he adds: "It is therefore practically certain that A and B C form a physical system." A is the bright star, and B C the double companion. The measures of B C referred to by Burnham are as follow:—

	°	″		
1898·87	178·0	0·16.	3 nights.	Aitken.
1898·88	178·4	0·12+.	1 ,,	Hussey.
1899·17	196·2	0·12.	1 ,,	Aitken.

The components were probably near periastron when Burnham tried to measure the star in the years 1889-1892.

I should not have mentioned these stars in my paper if there was any doubt as to their existence.

Mr. Holmes is mistaken in thinking that I "use the word brightness indifferently for quantity of light and surface brilliancy." The term "brightness" in my paper means "quantity of light," and not "surface brilliancy." The latter is not referred to at all in my paper, except in the case of Sirius and its satellite, and then I use the term "inherent light."

J. E. Gore.

Dublin, November 3rd.

RADIUM AND THE SUN'S HEAT.

TO THE EDITORS OF KNOWLEDGE.

Sirs,—It is supposed to be not yet settled whether the energy of radium comes from within or without. Up to now most has been heard in favour of the former view, which has included the contention that nothing can be done to a radium compound to lessen or destroy its *radio-activity*. This, I think, I have experimentally disproved (*vide Chemical News*, October 23rd, 1903, p. 206), and as an advocate of the theory that radium compounds derive their energy from without, as in other phenomena of absorption of radiant energy, I ask whether the time is yet ripe for cosmic hypotheses based on the opposite view?

Halifax, Yorks., November 2nd, 1903. William Ackroyd.

PROTECTIVE RESEMBLANCE IN BUTTERFLIES.

TO THE EDITORS OF KNOWLEDGE.

Sirs,—Mr. Rogers' letter in the September number of Knowledge on protective resemblance in butterflies opens up a fairly large question. In a note by Mr. Carpenter, I see this resemblance is attributed to natural selection both with regard to the Brazilian butterflies and in the moths which assume a smoke-colour in our own country.

With regard to the former, it would be most interesting to know how long a time was occupied in their becoming like the granite; but with regard to the effects of the smoke of London and other towns, such moths as *betularia* and *abruptaria* have certainly got darker in our own time, which hardly coincides with the working of evolution, which is generally so slow as to be almost imperceptible.

In the *Trans. Ent. Soc. Lond.*, 1903, there is an article on the experiments carried out by Prof. E. B. Poulton on the colour-relation between lepidopterous larvæ and their surroundings. These exhaustive experiments fully prove that the larvæ of *O. bidentata* and *G. quercifolia* are so

extremely sensitive to the colour of their close surroundings that if they be moved from a dark stem to a piece of lichen, for instance, and nothing else be given them to rest on (neither of them rest on their food-plant), they will, like the chameleon, in a few days change their pattern from dark to speckled, and be again invisible.

May not this colour sensitiveness *in certain individuals* be responsible for much that is put down to natural selection, and account for the many glaring failures that occur in the principle of protective resemblance?

Royal Societies Club, Jos. F. Green.
12th November, 1903.

MOCK-SUNS.

TO THE EDITORS OF KNOWLEDGE.

Sirs,—Colonel Markwick gives (p. 231) such a description of mock-suns that it seems needless to add more, beyond saying that they are caused by refraction from ice-prisms; and also that the clouds on which they appear may be so thin as to be imperceptible otherwise, and yet capable of producing bright mock-suns, as seems to have been the case on the occasion mentioned by Lieutenant K. D. Field (p. 206).

Sunderland, T. W. Backhouse.
21st October, 1903.

IS THE UNIVERSE FINITE?

TO THE EDITORS OF KNOWLEDGE.

Sirs,—Dr. Wallace's new book will no doubt renew the controversy on this question. I therefore ask space for some considerations as to the consequences of the finiteness of the Universe which do not seem to be sufficiently recognised.

If the Universe consists of a finite number of finite bodies I apprehend that it must have had a beginning in time, which drives us back to creation *a nihilo*. Take, for example, the Meteoritic theory, or that of Professor Bickerton. All heat—at least all intense heat—is the result of collision. But in all collision motion (molar motion) is destroyed, and in fact the amount of motion destroyed is proportional to the amount of heat developed. A finite Universe is only capable of containing a limited amount of motion or motive energy—for I suppose it will be admitted that the velocities with which bodies originally moved were not infinite. How, then, if matter has existed from eternity *a parte ante*, is there any motion still left—how is it that all bodies are not now collected in a single motionless mass? It is true that there are decreasing series, the sum of which will always be finite, although the series is carried to infinity. But the explanation of this fact is that after a very large number of terms the amount of each succeeding term becomes so minute as to be negligible. No advocate of Meteoritic or Collisional theories will admit that collisions have now attained this utter insignificance. Indeed it is maintained that they still occur on a large scale and produce very sensible effects, and this not at long intervals of time but constantly. Creation *a nihilo*, or the transformation into matter of something which in its original condition was quite unlike matter, seem to be the only alternatives.

The Nebular theory leads to a similar result. The great agent is here the radiation of heat into space, owing to which the nebula contracts until it becomes solid, becoming by a rather paradoxical law hotter as it loses heat. But if this process has been going on from eternity *a parte ante* in a finite Universe—the original nebula or nebulæ of course containing a finite quantity of heat or motion convertible into heat, how could there be *any* nebulæ left at the present day? But I need say nothing as to their actual number, and there is reason to think that besides those known to us there are vast numbers of them giving little or no light, the contracting process not having as yet proceeded far enough to render them self-luminous. Any other theory that I know of leads to a similar result. A finite Universe must ultimately reach a stage at which further changes are impossible unless it is so constituted that the series of changes will return in cycles—which is also impossible if it is constantly losing heat without any return.

I have never seen the proof of Lane's law with regard to the contraction of gases, but I should be glad if any of your readers could tell me whether according to it the radiation of heat from a gaseous body increases or diminishes while it is contracting. The increased temperature implies greater radiation from each square foot of the surface, but the contraction implies that the number of square feet in the surface is diminishing. Which of these causes is the more potent? If the latter, contraction due to the loss of heat can never increase the total radiation of heat from the contracting body. The shape of the body is, I presume, to be unaltered by the contraction.

I desire to correct one portion of my former letters. The comparisons between the light of the full moon and that of the sun were, I believe, made between the full moon and the hemisphere of the sun turned towards us, and not the light of both hemispheres as I had supposed. Hence all my figures should have been doubled, by which my argument is strengthened.

W. H. S. Monck.

ON RESOLVING THE GASEOUS MOLECULE AND SEEING IT.

TO THE EDITORS OF KNOWLEDGE.

Sirs,—I think the following will greatly interest your readers. Fill a thin flask with dry pure chlorine gas and a small quantity of dry air. Illuminate the gases with the light from the electric arc lamp, concentrated as much as possible. The gaseous molecules are distinctly visible with the naked eye. They are very small spheres of equal dimensions.

West Dulwich, S.E., Fredk. Hovenden.
October 26th, 1903.

GASEOUS NEBULÆ.

TO THE EDITORS OF KNOWLEDGE.

Sirs,—The idea has occurred to me that possibly the phosphorescent glow of the gaseous nebulæ may be due to the presence of radium in the gaseous state; in other words, that the unknown element "nebulium" may be identical with radium. Has the spectrum of radium been well determined, and, if so, does its spectrum contain a line near that of "the chief nebular line" at λ 5005?

J. E. Gore.

Dublin, 1903, October 25th.

Notes.

Astronomical.—Valuable additions to our knowledge of the phenomena of new stars are resulting from investigations at the Lick Observatory which are being made with the instrument specially designed for very faint objects. It has previously been found that Nova Cygni (1876) now exhibits no bright lines, and it is now stated that Nova Aurigæ (1892) is approaching the same condition, the chief nebular line having disappeared and other bright lines having become weaker in proportion to the

continuous spectrum. In Nova Persei, the nebular line is still bright, but striking changes have been noted in other lines. Nova Geminorum is still at an early stage, the nebular line continuing to increase in relative intensity. It is considered that the spectra of the three recent Novæ, like the spectrum of Nova Cygni, are destined to attain the same character as that of the great majority of the stars, and that the whole cycle of changes will occupy but a few years.

As a result of the application of a very powerful spectrograph to the determination of the surface velocity of the planet Venus, Mr. Slipher, of the Lowell Observatory, finds that the rotation period of the planet is much greater than the twenty-four hours assigned by some observers, and though no numerical result is derived from the observations they tend to confirm the longer period of 225 days arrived at by other observers.—A. F.

Botanical.—Hooker's "Flora of British India," a work of seven thick octavo volumes, the elaboration of which occupied nearly a quarter of a century, is likely to remain for a long time the standard general Flora of the Indian Empire. Since its completion, however, in 1897, several Indian local Floras have appeared, more or less based on Hooker's Flora, which will prove a boon to those who wish to limit their study of Indian botany to the flora of some presidency or well-defined district. A "Forest Flora of the School Circle, N.-W.P.," by a native botanist, U. Kanjilal, was issued in 1901. Dr. Theodore Cooke has undertaken the "Flora of the Presidency of Bombay," of which the first volume, containing Ranunculaceæ to Rubiaceæ, has appeared. A work which employed many of the latter years of the life of the late Sir Henry Collett was the "Flora Simlensis: a Handbook of the Flowering Plants of Simla and the Neighbourhood." This was published last year, shortly after the author's death. Besides an interesting introduction by Mr. W. Botting Hemsley, it has two hundred illustrations, which the student will find of much service in the work of identification. Mr. J. S. Gamble's excellent "Manual of Indian Timbers," of which a new and revised edition appeared last year, appeals especially to the forester. The latest local Flora is Mr. J. F. Duthie's "Flora of the Upper Gangetic Plain," &c. Part I., containing Ranunculaceæ to Cornaceæ, has just been issued. All these works are in English, and are as concise as is compatible with utility. Though no attempt is being made here to draw attention to all the important publications on Indian botany, reference should be made to the fine series of profusely illustrated monographs which have appeared in the "Annals of the Royal Botanic Garden, Calcutta." *Ficus*, *Quercus*, *Pedicularis*, *Anonaceæ*, *Orchidaceæ* and *Bambuseæ*, are the principal genera or orders dealt with.

In the Kew Museums is preserved a remarkable proliferous pine cone about which Sir W. T. Thiselton-Dyer has a note in the September number of the "Annals of Botany." The specimen was sent to the author of the note by the late Comte de Paris, in 1894, having been found on his estate near Seville, in Spain. The cone is that of the "Stone Pine" (*Pinus Pinea*), a species which produces edible seeds, these being strung together and sold in the markets of Lisbon. A normal cone is about six inches long, but that here referred to is only three and a half inches long, the diminution in size being due to the smaller number of scales. When found it was lying on the ground and bore a shoot at the apex about six inches long. It was taken home by the Comte de Paris and left on a table, where it continued to grow for a month, making a stem more than a foot long, and having three branches. Growth then suddenly ceased, and in spite of every attention the shoot withered and died. This is the first case recorded of terminal prolification in a pine cone. —S. A. S.

Zoological.—According to Mr. J. L. Bonhote (*Zoologist*, 1903, October), the Cambridge Museum possesses an undoubted British-caught specimen of the mouse-coloured bat (*Myotis murinus*, or *M. myotis*), taken at Girton, in 1888, by a lady student. The only previous British record was based on specimens taken some time before 1855 in the grounds of the British Museum. These specimens have been lost sight of. The Girton specimen, Mr. Bonhote thinks, was probably brought from the Continent with plants or other produce.

In a recent issue of the *Proceedings* of the Cambridge Philosophical Society, Prof. Ridgeway announces that he believes the thoroughbred horse to be descended from Grévy's zebra (*Equus grevyi*) of North-east Africa. A more astounding statement could scarcely have been made in a scientific journal, especially when it is borne in mind that the Professor derives horses, other than thoroughbreds, from the prehistoric horse of Europe. That is equivalent to saying that two strains, so alike in general characters as are the thoroughbred and the ordinary "cold-blooded" horse, are the descendants of totally different species, one of which was uniformly coloured, while the other was striped! Prof. Ridgeway also states that the prehistoric European horse was only ten hands high, or about the size of a Shetland pony. We wonder whether he has ever looked at the series of cannon-bones of the prehistoric horse in the Natural History Museum, and compared them with the corresponding bones of recent horses.

A new generic type of marine turtle (*Eochelone brabantica*) from the Middle Eocene of Belgium, is described by Mr. L. Dollo, in the *Bulletin* of the Royal Belgian Academy. In the forward position of the inner nostrils, as well as in the shortness of the union between the two branches of the lower jaw, this species differs from the true turtles of the present day, and approximates to the luth, or leathery turtle (*Dermochelys*). Moreover, both the upper and lower shells are much reduced, and show many vacuities. These features serve to confirm the view that the luth is a specialized form derived from the ancestors of the true turtles. Nevertheless, on account of its peculiar unattached "mosaic" carapace, Mr. Dollo considers that, together with the extinct *Psephophorus*, it should represent a family by itself. On the other hand, all the other turtles including the luth-like *Eosphargis* of the London clay, should be placed in the family *Chelonidæ*, on account of their possessing, albeit in some cases in a rudimentary condition, a carapace attached to the ribs.

The function of the so-called labyrinth of the internal ear of fishes, forms the subject of a paper by Mr. T. Tullberg, published in the *Bihang* of the Swedish Academy. Although this structure may also act as an organ of hearing, the author is of opinion that its principal function is to take cognizance of the movements of the water in which fishes live.

Glyptodons, or giant extinct armadillos, were long supposed to be confined to South and Central America. Some years ago their remains were, however, discovered in Texas; and recently Prof. H. F. Osborn (*Bull. Amer. Mus.*, Vol. XIX., p. 491) has described and figured a very fine carapace and tail-sheath of one of these strange monsters from the latter state. It is regarded as representing a new generic type, under the name of *Glyptotherium*.

The extinct three-toed horses of North America have hitherto been regarded as generically inseparable from the European *Hipparion*, and it was suggested by the late Prof. Cope that the modern horses have had a dual origin from the hipparions of the Old World on the one side, and from their American representatives on the other. Recently Mr. J. W. Gidley, in the *Bulletin* of the American Museum, has come to the conclusion that the New World hipparions are generically distinct, and he proposes that they should be known as *Neohipparion*. They differ from the Old World forms by certain details of tooth structure, as well as by their more slender limbs, in which it seems that the lateral toes are relatively smaller. Finally, they are of Miocene, instead of Pliocene, age.

GEOGRAPHICAL.—*Northern Nigeria.*—On November 4th Sir Frederick D. Lugard read a paper on Northern Nigeria before the Royal Geographical Society. After briefly dealing with the history of the country, the High Commissioner gave some interesting details regarding the native races. The Mohammedan Fulanis were, generally speaking, the ruling race. Originally herdsmen, they had become invaders and conquerors by the necessity of finding fresh grazing-grounds. It was curious that, while one section of them supplied the ruling dynasty, the other remained herdsmen, and occupied often an even more servile position than the conquered Bantu races. Although the Fulani had degenerated, and had become detested for their mis-rule, Sir Frederick Lugard believed that the future of the virile races of the protectorate lay largely in their regeneration. The indigenous people were of many different tribes. Of these the Hausas were the most considerable. Their language was the *lingua franca* of Northern Nigeria, especially of trade, and their keen commercial instincts had earned for them the name of "the business-men of West Africa." They made admirable soldiers, and were brave and reliable, but probably inferior in mental ability and alertness to either the Nupes or Yorubas. The latter were hardly less keen traders than the Hausas—at least equally industrious, and much quicker to learn—though hardly equal to them in stolid pluck. The Nupes were the finest of the three in physique, and were very intelligent; but they had not the pluck of the others, and their ability was apt to degenerate into cunning, treachery and falsehood. These tribes had, to some extent, embraced the faith of Islam, especially the Hausas. There were other great tribes who were pagans. In a short account of the physical geography of the province, Sir Frederick Lugard spoke of the annual rise of the Niger, upon which its navigability depended. The annual rise caused by the rains occurs in August and September; but since the river rises in the zone of heavy rainfall, and the lakes around Timbuktu form a vast storage, the surplus water, traversing 2000 miles of country before it again reaches lat. 10°, causes a second flood towards January, and thus tends to keep the whole river at a higher level for the greater part of the year.

"FOUR YEARS' ARCTIC EXPLORATION, 1898–1902," was the title of Commander R. E. Peary's lecture to the Royal Geographical Society, on November 10th.

During 1899, material was obtained for the accurate mapping of Buchanan Bay, the Bache Peninsula, and the Princess Marie Bay region in Ellesmere Land.

In 1900, an important year's work was accomplished by a long sledge journey along the north-west coast of Greenland. Arrived after much hard work at Cape Washington, Commander Peary found, to his delight, that this was not the most northern point of Greenland, as hitherto supposed. Still further to the north-eastwards he eventually rounded it, and had the satisfaction of being the first to tread this most northerly known point of land in the world. The non-existence of land far to the north and north-east led him to conclude that an uninterrupted sea stretched from this point across the Pole even to Spitzbergen and Franz Josef Land on the opposite side. An observation of extreme interest was that at this most northerly point of land, surrounded as it was by everlasting ice, so large an animal as the musk-ox was found, besides hares, foxes and lemmings, and such land birds as the snowy owl, the ptarmigan, and the snow bunting.

In 1901, Commander Peary again left Conger on another expedition, but on reaching Lincoln Bay the condition of men and dogs was such that he was forced to return.

In 1902, starting from Payer Harbour and proceeding up the east coast of Ellesmere Land, Commander Peary made a rush for the Pole, but succeeded only in reaching north latitude 84° 17′ 27″. In his various lengthy sledge journeys Commander Peary has been very greatly assisted by a number of Esquimaux, while his sledges have been drawn by teams of dogs, we presume of the Esquimaux and not of the Samoyed breed used by Dr. Nansen, the Duke of Abruzzi and others. In his lecture Commander Peary spoke very feelingly about these Esquimaux and the dogs, but we think it a great pity that he should have dwelt so much upon the hardships and difficulties encountered, while by his repeated appeals to the sentiments of his audience his lecture, taken as a scientific discourse, was, in our opinion, much deteriorated.

Next year (1904) Commander Peary hopes to start again for the west coast of Greenland. This time he will endeavour to get his boat so far north that he will be able to winter on the northern shore of Grant Land. Should he be able to do this he would be in a position, with the help of his Esquimaux and his dogs, to reach the Pole by a sledge journey of considerably shorter length than the average length of his several former journeys, which had as their base a much more southerly point.

Conducted by HARRY F. WITHERBY, F.Z.S., M.B.O.U.

Aquatic Warbler in Ireland (Irish Naturalist, 1903, November, p. 300).—Mr. R. M. Barrington records that an immature male specimen of the Aquatic Warbler *(Acrocephalus aquaticus)* has been sent to him from the Bull Rock Lighthouse, Co. Cork, which it struck on September 20th last. The Aquatic Warbler, which is common in Central and Southern Europe, has not been recognised before as occurring in Ireland. Only some eight specimens have been recorded for England, probably owing to this bird's similarity to the Sedge Warbler.

Orphean Warbler in Sussex.—At a meeting of the British Ornithologists' Club, held on October 21st last, Mr. W. Ruskin Butterfield exhibited a female specimen of this Warbler, which had been shot near St. Leonards-on-Sea on October 7th. The Orphean Warbler is a common summer resident in many parts of Southern Europe, and

in Asia Minor, but a thoroughly authenticated instance of its occurrence in the British Islands has hitherto been wanting.

Black-winged Pratincole in Sussex and Kent.—At the same meeting Mr. Boyd Alexander exhibited an adult female specimen of the Black-winged Pratincole *(Glareola melanoptera)* which had been shot in Rye Harbour on the 18th of June last. Mr. Alexander also noted that an adult male had been shot on June 17th on Romney Marsh. These two specimens, with the one previously obtained on Romney Marsh, and already recorded (Knowledge, 1903, August, p. 184), probably visited our shores in company.

Great Reed Warbler in Sussex.—Mr. M. J. Nicoll exhibited at the same meeting a specimen of the Great Reed Warbler *(Acrocephalus turdoides)* which he had shot on September 25th, 1900, near St. Leonards. There are only four previous authentic records of the occurrence of this bird in Great Britain, although it is very common near at hand on the Continent, and its loud voice would be likely to prevent it from escaping notice had it visited this country more often.

Tawny Pipit in Kent.—Mr. Nicoll also exhibited two Tawny Pipits *(Anthus campestris)*, shot at Rye Harbour on September 22nd. It is curious that this bird is not more often recorded as a visitor to the British Islands (it has been noticed some twenty or thirty times), since it breeds as near to us as the North of France and Holland, while it is very common in Southern Europe and North Africa.

Report on the Movements and Occurrence of Birds in Scotland during 1902. By T. G. Laidlaw, M.B.O.U. (*Annals of Scott. Nat. Hist.*, 1903, pp. 78–79, 144–153, 205–210).—This yearly report is very useful, but the records are becoming so numerous that it may be found advisable in future to omit some of the details, and to summarize the observations.

All contributions to the column, either in the way of notes or photographs, should be forwarded to Harry F. Witherby, *at the Office of* Knowledge, 326, *High Holborn, London.*

Notices of Books.

"The Geography of Disease." By Dr. F. G. Clemow. Pp. xiv. and 624. (Cambridge University Press.) 15s.—This is one of the most important contributions to scientific literature that has come under our notice for some time. Though the area of distribution of disease parasites is not the same as that of the human diseases caused by them, the more the student of pathology knows about both the better it is for mankind in general. In many cases the reason why certain diseases are endemic in some districts and absent from others admits of simple explanation, but there are numerous cases where the relationship between cause and consequence cannot be so clearly seen. Some diseases, such as measles, typhoid fever and whooping cough, occur in all parts of the inhabited world; scarlet fever and diphtheria are found mainly in temperate and cool climates, while malaria and dysentery are most frequent near the tropics. Cholera, plague and yellow fever is endemic in certain limited areas, but at irregular intervals they spread to almost any part of the world. Then, again, some diseases seem to be antagonistic to others; thus, the diminution of malaria in many European countries in recent years has been concurrent with an increase of cancer in the same countries, and the fact suggests a relationship between the two diseases. With the material which Dr. Clemow has so industriously collated, it becomes possible to make a scientific study of the distribution of the various diseases to which human flesh is heir, and to consider the factors which determine the range of the maladies. To students of geographical and historical pathology the book will be an invaluable work of reference. With colonies in all parts of the world, it is of the highest importance that our medical graduates should be in possession of the volume which Dr. Clemow has prepared; and the lay public will find so much of interest in it that the book should be added to every reference library.

"The Wonderful Century: The Age of New Ideas in Science and Invention." By Dr. A. R. Wallace. Pp. xii. and 527. (Swan Sonnenschein.) 7s. 6d. net.—So far as we know there does not exist a better popular account of the nature and growth of science and invention during the past hundred years than is given by Dr. Wallace in this volume. The first edition was good, but the present edition is even more valuable, and should command a large circle of readers. The long chapter on vaccination has been omitted, the chapters on locomotion, photography, and chemistry have been extended, and new chapters have been added on electrical and astronomical advances. Scarcely a subject of importance has been overlooked, so that the volume gives a broad view of the present state of knowledge and conditions of living. Radium is briefly mentioned, and among other matters surveyed are the liquefaction of gases, colour photography, and the evolution of chemical elements. Special attention is given to the author's view that the solar system is at or near the centre of the universe. The section on wireless telegraphy is, however, scarcely up-to-date, for as messages have been exchanged from one side of the Atlantic to the other, the remark that the distance across which messages have been sent "has been extended to two hundred miles, between the Isle of Wight and Cornwall," is somewhat behind the times.

"Cohen's Physical Chemistry." Translated from the German by Martin H. Fischer, M.D. (Bell.) 6s. net.—We can heartily recommend this little book to anyone desirous of becoming acquainted with the principles of physical chemistry. It has 343 pages, is well illustrated, and is provided with numerous references to the leading scientific journals. So many books of this kind are liable to become unreadable lists of facts, but the present author's style is interesting and lucid, and entirely free from technical mannerisms. The lectures on electrolytic dissociation are exceedingly good. The theory of Arrhenius, and the various methods employed in determining the extent of the dissociation of electrolytes in solution, are by no means easy to grasp when met with for the first time, but the lucid way in which Prof. Cohen treats the subject causes most of the usual difficulties to disappear. The author has greatly added, also, to the value of his book by showing the relations which exist between physical chemistry and biology, and by revealing many fields for research, the pursuit of which would prove of untold profit to medical men and biologists.

Dr. Fischer is to be congratulated on the able way in which he has effected the translation.

"Steel and Iron." By A. H. Hiorns. Pp. xvi. and 514. (Macmillan.) 10s. 6d.—Mr. Hiorns has produced several excellent text-books on metallurgy, and many students will be glad that he has now facilitated their studies by bringing together the essential points of papers published at home and abroad on various aspects of the iron and steel industries. It is no easy matter to assimilate and present in a digested form the mass of literature of real significance in any scientific subject, and the author who attempts this task deserves well of his generation. Mr. Hiorns does not pretend to have taken account of more than a small proportion of published papers on iron and steel, but he does give the results and conclusions of leading authorities, so that the student of metallurgy is able to take a view of the subject in the light of recent theory and experience. The descriptions are concise, well illustrated, scientific and practical, and the book as a whole is a credit both to the author and publisher.

"A Manual of Palæarctic Birds." By H. E. Dresser, F.L.S., F.Z.S. (Published by the Author at 3, Hanover Square, W.) 2nd part. 12s. 6d.—In a notice of the first part of this work (Knowledge, 1903, July, p. 158) complaint was made of the omission of many described forms which were entitled, in our opinion, to rank equally in point of distinction with many which had found a place in the volume. In the preface to the work, which is included in the part now under review, Mr. Dresser gives a curious reason for these omissions. After referring to the dangers of the "endless manufacture of sub-species," the author declares that he has "declined the recognition of such so-called 'sub-species' as those who have described them have so little confidence in as to need the aid of trinomials." Granted that it was wise to omit from a work planned for field-naturalists the sub-species least easily distinguishable, a proper standard for selection was of the utmost importance. Mr. Dresser's resolution to omit those forms described under a more modern system than that used by him was a great error of judgment, and an inconsistent selection of the forms treated of in the work has been the natural consequence. Notwithstanding this serious fault, the work will be found very useful in many ways. The arrangement is excellent, and a great amount of good information is compressed into a very small space. Besides the scientific appellation, the name of each bird is given in

English and several other languages. A description of the species, a statement of its range, and an account of its habits, follow in concise form. The book should be exceedingly useful to the traveller, provided he bears in mind that very many distinct geographical forms have been entirely omitted.

"Agricultural Geology." By J. E. Marr, M.A., F.R.S. Pp. xii. + 320. (Methuen.) 6s. Illustrated.—This book is written to suit the requirements of candidates for the International Diploma of Agriculture. It suffers to a certain extent from the apologies which its author so frequently makes for passing over interesting and even important portions of his subject. Either so admirable a teacher of geology should not undertake to write a text-book which cannot appeal to him as a work of art, or he should imbue himself with the peculiar needs of his readers, and give the book the appearance of a continuous narrative, which shall captivate the student, and entrap him towards something higher. No two writers will agree precisely as to what shall be omitted in the "acting version" which they place before the public. We, for instance, should have laid stress on the iron-ores as ingredients of soils (p. 38), seeing that the muddy streamlet and the warm brown new-ploughed land alike owe their colour to limonite, and ultimately to magnetite, and ferriferous silicates, a fact well recognised on p. 88. We should have omitted mention of nitre (p. 33), used mainly for gunpowder, but should have given the precise chemical composition of Kainite and Carnallite, and have explained why this is not realised in commercial samples (pp. 33 and 309). The origin of these salts forms one of the most fascinating chapters in geology; and agricultural students are not the mere "practical" persons referred to on p. 307. They are unwittingly concerned with the most poetic and natural of all professions; and the geologist may be proud to meet them on the question of the regeneration of the earth. We admire Mr. Marr's clear treatment of denudation, and of the resulting surface-features (pp. 81-134). Here the agricultural requirements in soils are stated in a very concise form, the author evidently desiring to avoid overlapping on other branches of the curriculum. His use of "lime," however, for "carbonate of lime," is too great a concession to agricultural custom (p. 96). Still more excellent is the section on geological surveying (pp. 143-210), which will make the published maps appeal in all their detail to the reader. The concluding chapters on stratigraphical geology are inevitable, owing to the requirements of examiners; but they naturally challenge comparison with many ordinary text-books of geology. We confess that we should like to see the physical part of the book expanded, and the pupil left to study in detail the country in which he proposes to found his home. The British Isles, by which public examiners mean England and a part of Wales, have too long been made a fetish; and students will rattle off the succession of Jurassic strata near Leckhampton who have no conception of some of the most important epochs in the evolutionary history of the globe. Mr. Marr must have felt himself again and again hampered in the preparation of the present treatise, which does not rival those well-known books in which he struck across new country.

"Mostly Mammals." By R. Lydekker. 383 pp. 1903. (Hutchinson & Co.)—This is a volume of collected essays, which "have previously appeared in periodical literature; the great majority in Knowledge, but others in *Nature*, the *Field*, and the *Asian*." Save in a few instances only, these essays are presented in their original form or "with such alterations as have been found necessary in order to bring them up to date, and with a few omissions to avoid unnecessary repetition. A certain amount of repetition will, indeed, still be found to exist, as somewhat similar ground is, in certain instances, traversed in the course of two separate articles. To have avoided this would have entailed practically re-writing some, or the total omission of others." We cannot but regret that this plan of issue was decided upon, since some of the articles would most certainly have been improved by re-casting and addition. Nowhere is this more noticeable than in the chapter on "Animals Exterminated during the Nineteenth Century," which occupies rather less than seven pages. Again, the chapters on "The Coloration of Large Animals," and "Spots and Stripes in Mammals," would undoubtedly, if re-cast and made to form a single essay, have gained in value. It is scarcely necessary, in the pages of Knowledge, to indicate further the nature of the contents of this book and, doubtless, the intrinsic merit of those articles which have appeared in this journal will induce the readers thereof to buy the volume for the sake of the essays which have appeared elsewhere.

"A Naturalist's Calendar, kept at Swaffham Bulbeck, Cambridgeshire, by Leonard Blomefield (formerly Jenyns)." Edited by Francis Darwin. Pp. xviii. + 84. (Cambridge University Press.)—Mr. Blomefield was an accurate and painstaking naturalist, whose nature calendar was founded on observations made near Cambridge between the years 1820 and 1831. Every Cambridgeshire naturalist will be glad to possess a copy of this calendar, which shows the average date of appearance and of various stages of development of plants and animals, and the earliest and latest occurrence of each phenomenon. Mr. Darwin, in an appreciative introduction, points out that Mr. Blomefield was known for his minute and scrupulous exactness in matters of fact, so that his record is of real scientific value, as well as being of interest to the amateur naturalist. By means of the calendar and its index it is easy to find the mean, earliest and latest dates on which birds appear, commence and cease to sing; when the leaves of plants are seen and flowers open and fruit appear; as well as of many other phenological phenomena. The common as well as the scientific names are given, so that the calendar can be consulted and understood by anyone interested in outdoor life. The dates only apply, of course, to the Cambridge district, and very decided differences will be noticed by naturalists in other places. Our field clubs should always keep in mind that they cannot perform a more useful and appropriate work than that of preparing and publishing such records.

"Smithsonian Physical Tables." Prepared by Prof. Thomas Gray. Second Revised Edition. Pp. xxxiv. + 301. (Washington: Smithsonian Institution.)—The publication of tables of trustworthy results in physics, meteorology and geography, is one of the many ways in which the Smithsonian Institution assists scientific progress. To the student of science and to the investigator it is very convenient to be able to refer readily to the values obtained by well-known authorities, whose methods of experiment and careful work give reason for confidence in their results. In the volume before us tabulated values are given for practically every physical constant or relation, with references in most cases to the publication from which the results have been obtained. Mathematical tables are also included, and the whole is well indexed. Separate volumes are published for geographical and meteorological data, but revised editions of these have not been published for some years. It would be an advantage if revised editions, in which new results are included, could be published every year or so.

"The Cloud World: its Features and Significance." By Samuel Barber. Pp. vii. + 139. (London: Elliot Stock.) Illustrated. 7s. 6d.—The value of this book lies in the original observations it contains, and in the excellent illustrations, many of which have already appeared in the pages of Knowledge. Mr. Barber is an enthusiastic student of clouds and related phenomena, and his volume directs attention not only to their beauty of form, but also to their relation to weather. He states his observations as matters of fact, and in most cases is content to leave their theoretical significance out of consideration. Years of study have enabled Mr. Barber to know "the balancing of the clouds," and to read forthcoming weather from the signs of the sky. He recognises that many cloud phenomena are local; nevertheless, the results of his studies are applicable to any part of the British Isles, and can be consulted profitably by all who wish to understand the messages carried by clouds of various types. Sun-pillars, waterspouts, colour of sky, and auroral displays are among other subjects described, mostly from the author's own experiences. Finally, there is a descriptive list of clouds of many kinds, with fine pictures reproduced from photographs, so that anyone who cares to take up the study of clouds will find the book both inspiring and instructive.

"Limanora: The Island of Progress." By Godfrey Sweven. (Putnams. 1903.) 6s.—An Utopian romance that is founded on science to an extent unapproached by any of its predecessors in that department claims notice in a scientific periodical. This novel with a Maori-sounding name is, perhaps, the first of its kind to be saturated with the idea of evolution and all its kindred conceptions. A mere enumeration of the new scientific ideas which its author's keen curiosity and adventurous

spirit have gathered from all sources and added to from his own imaginative stores would be a long one. Limanora is an island in the South Seas—somewhere, we conjecture, in the neighbourhood of the sunny isles of New Zealand. It is inhabited by a race which a prolonged selection and adaptation (for the author is both Darwinian and Spencerian) have endowed with new powers of flight and locomotion, new senses, a new command over nature, won by the legitimate means of scientific discovery, and an unique civilisation that is evidently the author's ideal of society. We are gradually initiated in the secrets of the outer and inner life of the Limanorans by an attractive account of the author's education as one of their adopted citizens. Evidently a sufferer from insomnia, he finds in Limanora new appliances (magical in effect, but scientific in construction) that make sleep and rest a source of exhilaration and of replenished stores of energy. The modes of locomotion are as numberless as the modes of rest. He is taught to fly, but imperfectly, because his body, unlike the Limanoran, has not been adjusted to the new conditions by the selection of his ancestry. A hermit by vocation, he rejoices to live with a race that condemns gregarious education as encouraging atavism and restricts social intercourse. A visit to the Valley of Memories revealed the successive stages through which the race had passed. He saw the origin and traced the evolution of each new faculty, power, and virtue. He was taken to their great repository of force, and here the glowing imagination of the author finds ample scope in describing the numberless modes in which the force of the winds, the waves, and the sun is trapped, stored and applied. The halls of nutrition and medication showed how perfect a command the Limanorans had gained over all the processes of health and disease. A consequence of the physical evolution of the Limanorans was the genesis of a magnetic or electric sense out of the magnetism latent in all human beings. We have no space to describe the wonders it reveals or the marvels of another faculty by which solid and beautiful structures are raised, like the walls of Thebes, to the sound of music. After he had seen a storm-cone that diverted both tempests and clouds of death-bearing dust as they approached the island, his education was resumed. His eyesight was so strengthened that he could see into the interior of objects. He acquired the new electric faculty, with all its resources. His auditory powers were increased. His lower senses were intellectualised. His nerves were refined. He mastered the fine *outillage* that had been evolved *pari passu* with the evolution of the senses. Thus equipped, he became a citizen of his ideal commonwealth and was initiated into its inner life. He tells of its polity, its literature, ethics, and religion. In all these departments the Limanorans seem to have made advances that we may emulate. For the story is no mere dream, but a vision that is possibly within measurable distance of realisation. Embodying thoughtful and original *aperçus*, it is a most inspiring book. By its wealth of ideas, the solidity of its scientific foundation, and its excellence of literary form, it surpasses most Utopian romances, from Plato to Bellamy.

BOOKS RECEIVED.

Central Asia and Tibet. By Sven Hedin. 2 vols. (Hurst & Blackett.) Illustrated. £2 2s. net.

Man's Place in the Universe. By Alfred R. Wallace, LL.D., D.C.L., F.R.S. (Chapman & Hall.) 12s. 6d. net.

British Mammals. By Sir Harry Johnston, HON. D SC.(CAMB.). (Hutchinson.) Illustrated. 12s. 6d. net.

Aether and Gravitation. By William George Hooper, F.S.S. (Chapman & Hall.) 12s. 6d. net.

Limanora: The Island of Progress. By Godfrey Sweven. (Putnam.) \$1·50.

Laboratory Physics. By Dayton Clarence Miller, D.SC. (Ginn.) 8s. 6d.

Mechanics, Molecular Physics and Heat. By Robert Andrews Millikan, PH.D. (Ginn.) 7s.

Bird Life in Wild Wales. By J. A. Walpole-Bond. (Unwin.) Illustrated. 7s. 6d.

Morphology of Spermatophytes and Part II. *Morphology of Angiosperms.* By John M. Coulter, PH.D., and Charles J. Chamberlain, PH.D. (Appleton.) Illustrated. 10s. 6d. net.

Animal Studies. By David Starr Jordan, Vernon Lyman Kellogg, and Harold Heath. (Appleton.) Illustrated. 5s. net.

School Arithmetic. (Universal Tutorial Series.) By W. P. Workman, M A., B.SC. (University Tutorial Press, Ld.) 3s. 6d.

Manual of Practical Mathematics. By Frank Castle, M.I.M.E. (Macmillan.) 6s.

The Evolution of Earth Structure. By T. Mellard Reade, F.G.S., F.R.I.B.A., A.M.I.C.E. (Longmans.) 21s. net.

Canada in the Twentieth Century. By A. G. Bradley. (Constable.) Illustrated. 16s. net.

The Analytical Chemistry of Uranium. By Harry Brearley. (Longmans.) 2s. net.

Official Year Book of the Scientific and Learned Societies of Great Britain and Ireland, 1903. (Chas. Griffin & Co., Ltd.)

Pitman's Shorthand and Typewriting Year Book and Diary for 1904. 1s.

On Liberty. By John Stuart Mill. (Rationalist Press Association.) 6d.

Haeckel's Critics Answered. By Joseph McCabe. (Rationalist Press Association.) 6d.

Experiments and Observations with Radium Compounds. The Colours of Iodides. By William Ackroyd, F.I.C., F.C.S. (*Chemical News* reprint.)

Rock Phosphates and other Mineral Fertilizers. By Charles Chewings, PH.D., F.G.S., &c. (Adelaide: C. E. Bristow.)

Graphs: or the Graphical Representation of Algebraic Functions. (University Tutorial Press, Limited.) 6d.

Calculating Scale, a Substitute for the Slide Rule. By W. Knowles, B.A., B.SC. (Spon.) 1s. net.

School Geometry. Part IV. By H. S. Hall, M.A., and F. H. Stevens, M.A. (Macmillan.) 6d.

Essex Field Experiments, 1896-1903. No. 2. *On Tillage Crops.* Compiled by T. S. Dymond, F.I C., and B. W. Bull, N.D.A. (County Technical Laboratories, Chelmsford.)

Continental State-Aid for Agriculture. By T. S. Dymond. (County Technical Laboratories, Chelmsford.)

Illustrated Catalogue of Astronomical Instruments, Observatories, &c. Sir Howard Grubb, F.R.S.

MICROSCOPY

Conducted by M. I. CROSS.

SHORT NOTES ON MICROSCOPIC ENTOMOLOGY.

By W. WESCHÉ, F.R.M.S.

THE GIZZARD OF THE EARWIG.—It is known that many of the *Orthoptera*, such as Grasshoppers and Crickets, have gizzards. The Earwig, (*Forficula auricularia*) is also well provided in this respect. The organ is in four parts, all four elaborately toothed and working one on the other. The teeth consist of a number of spines, having their blunt ends inserted into round sockets with raised edges.

Favourite food of this insect in the spring and summer is the Aphis, and if the stomach is carefully examined, the broken-up parts will be seen. The Aphis has two trumpet-shaped tubes on its back, which exude the fluid that the ants are so fond of. These will be usually found intact, but how they escape complete destruction by the gizzard it is difficult to say, at all events when seen they can be readily identified, and enable a determination of the contents of the stomach to be arrived at.

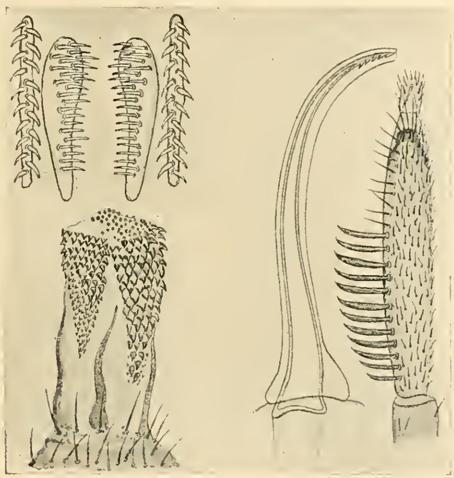
OVIPOSITOR OF THE FLY, *Phytomyza flava*.—There is a small family in Diptera, the *Phytomyzidæ*, which has a very characteristic ovipositor. In most flies this is a telescopic organ, membranous, and with rings and rods of chitin to extend it. In other families it is hard and horny, with a sharp point which enables the fly to insert her eggs under the cuticle of leaves. We see examples of these families in our common flower-haunting *Trypetidæ*. We can trace the progress of the larvæ by the marks on the leaves of such plants as the garden Marguerite (*Chrysanthemum leucanthemum*). The *Phytomyzidæ* have an ovipositor, which makes when mounted a beautiful microscopic object. It consists of a series of subtriangular horny scales, arranged more or less symmetrically. These working freely hollow out cavities in the soft parts of shrubs, which afford protection to the eggs of the insect.

THE MANDIBLES OF THE "APHIS LION."—The most complicated mandibles I know, are found on the larvæ of the lace-

wing fly, *Chrysopa vulgaris.* They are hollow, and inside, the maxillæ, (inner jaws) are fitted. Attached to the base of the maxillæ are powerful tendons, by means of which they are worked in and out of the mandible. So the larva is able to seize prey with the mandibles, and, still holding it, to pierce the skin with the serrated points of the maxillæ, and suck its fluids, an economy of means not often found in Nature. These larvæ are highly beneficial to our gardens, as they attack the Aphides. Their voracity is out of all proportion to their minute size, and has earned them the name of the "Aphis Lion." The eggs are curious; they are placed at the end of long stalks, and a number being always laid together, look like a little clump of fungus, and are easily identified.

HAIRS ON THE FORE-LEG OF THE FLY, *Empis tesselata.*—The hairs of insects modify into extraordinary shapes and forms.

1.



2. 3. 4.

1.—Gizzard of Earwig, *Forficula auricularia.* 2.—Ovipositor of the Fly, *Phytomyza flava.* 3.—Mandible of the "Aphis Lion," (larva of *Chrysopa vulgaris*), showing the maxillæ enclosed. 4.—Femur of the fore-leg of the Fly, *Empis tesselata,* showing the modified hairs used in holding prey.

In some of the aquatic Hemiptera they are seen as delicate filamentous veils, which hold the water and assist in the propulsion of the insect. In Diptera they have also very various and remarkable developments. We find them modified into hooks of an extraordinary multiplicity of shapes, and scattered all over the body of the insect, teeth, brushes, and, in *Empis tesselata*, into knife-blades, which, fixed into the femora of the fore-legs, enable the insect to securely hold its prey. In many species of flies the stronger hairs have a longitudinal striation. In these knife-blades the hair has flattened out, but the original striation remains. It is obvious that *E. tesselata* is predaceous, and has strong piercing lancets, as well as a well-developed suctorial organ in the mouth parts.

A LIVING FLY IN THE ACT OF FEEDING.—The method originated by the late Mr. R. Macer, for showing under the microscope a living fly, or similar insect, while feeding, is comparatively little known. It is very simple, always creates interest, and brings to view, in a manner which is otherwise impossible of appreciation, the mechanism of the proboscis.

The following are the necessary items for arranging the exhibit:—

1. Cones.
2. Forceps.
3. Glass bottle and tube.

1. *The Cone.*—Small cones, about $\frac{1}{16}$ in. diameter and about $1\frac{1}{8}$ in. high, are made of paper and firmly cemented, the tops are then cut off, leaving the apertures of varying diameter from $\frac{1}{16}$ in. to $\frac{1}{4}$ in. to suit different sized insects; the interior of the cone is dull blackened. These cones have subsequently to be gripped by forceps, and so that they may not slip, a narrow rim of either string or paper has to be cemented round them a short distance from the apex.

2. *Forceps.*—Two pairs are required, one to hold the cone and the other to carry a piece of blackened cardboard on which honey should be placed. Both of these forceps should be of the "stage" pattern, the former having at the end of the jaws a circular ring in which the cone is placed; the latter have the jaws mounted on a spring, so that a screw, which is carried on a bridge above, can be made to press on the jaws, and so cause them to recede or be brought nearer the desired object.

3. *A Glass Bottle and Tube.*—The former is to contain the fly, and may be of any ordinary variety; the latter is a plain glass tube having both ends free and fitted with corks.

Process of Exhibiting.—One of the corks is removed from the tube, which is then placed over the bottle in which the fly is contained, the cork of that also being removed; when the fly has entered the tube one of the cones is quickly placed over the free end, after which the cork at the other end is removed. A small plug of cotton wool is then inserted, and is gradually pushed upwards through the tube into the cone, the small opening of which is held towards the light so that the fly may put his head through. When it has arrived at this position the plug of cotton wool is carefully placed behind it.

The cone is now ready to go into the round-ended forceps, which are fixed on the stage in the usual manner. The other forceps carrying the cardboard with honey are placed in position on the other side of the stage, and the bait is placed quite closely to the fly's head. A $1\frac{1}{2}$ in. objective is then focussed, and the honey can be altered in position the desired amount, by means of the adjusting screw before referred to, until the proboscis is well displayed.

The best form of illumination is with a bull's-eye condenser and a parabolic side silver reflector.

A USEFUL DRYING OVEN.—Working microscopists often find a difficulty in providing a suitable place for unfinished slides, where dust cannot reach them, and in knowing how to dry them quickly and safely, more especially where space is limited and no suitable oven available.

Mr. L. Sandall, F.R.M.S., suggests the following method of making a small oven which will be found to answer the requirements of the average worker:—

Obtain a tin about 9 in. by $8\frac{1}{2}$ in. by 9 in., such as a 7 lb. size biscuit tin. It should be free from dents, and will need thoroughly cleaning with hot soda water and properly drying. It will require added to it four legs, preferably $\frac{3}{8}$ in. thick and 6 in. long, and half way down the interior, on either side, two strips of tin about 1 in. wide should be soldered and bent at right angles to form brackets, on which a piece of plate or window glass cut to the proper size could rest, and form a shelf to put the slides on.

In addition, a hole should be made at either corner on the top of it about 1 in. diameter, which can be plugged with a tightly-fitting cork, through which a thermometer can be passed to register the inside temperature. These little extra fittings will be made by any local tinsmith at very small expense.

It will be obvious that when completed the lid of the tin will not be uppermost, but when mounted on the legs will be at the front to form a door.

To give a finished appearance to this contrivance, the tin work may be cleaned and enamelled with Brunswick black.

The heating will be obtained by mounting a spirit or small paraffin lamp on blocks of wood of suitable size to maintain the temperature that is required.

Those who may prefer to be able to see into the tin should have the centre of the lid cut out and a square piece of window glass inserted, secured by strips of tin soldered round the inside.

WATERPROOF CEMENT FOR GLASS.—Many attempts have been made to produce a cement suitable for microscopists' use, for making and repairing troughs, aquaria, etc., that will hold water without leaking, and be unaffected by water. The two

following formulæ are given by *The Scientific American* for the purpose :—

1. Dissolve 5 to 10 parts gelatine in 100 parts water ; add 10 per cent. of a concentrated solution bichromate of potash, mix thoroughly and keep in a dark place. When the articles joined by this cement are exposed to sunlight for a short time, the cement becomes tough and insoluble in water.

2. Quicklime ... ... 4 parts.
Litharge ... ... 6 „
Linseed oil varnish ... ... 1 part.

A New Catalogue.—Mr. C. Baker, of 244, High Holborn, is now issuing a fresh edition of his Catalogue of Microscopes, for the year 1904. This list contains much valuable information, and describes instruments and accessories for every description of microscopical investigation. Reference to it indicates the fact that, by special arrangement, Powell & Lealand's well-known microscopes are now supplied by C. Baker. Also among other new items will be found an illustration and description of Dr. Spitta's Monochromatic Light Apparatus, which was described in these columns at the time of its exhibition at the Royal Microscopical Society. The excellent arrangements made in connection with the Slide-Lending Department are fully detailed, and altogether the Catalogue is one that every microscopist, who wishes to be conversant with the latest instruments and accessories for his work, must have among his reference books.

NOTES AND QUERIES.

Rev. M. C. H. Bird.—Either of the following books will meet your requirements :—"A Popular Hand Book to the Microscope," by Mr. Lewis Wright ; "Modern Microscopy," by Cross and Cole ; and, as a complete text book, "The Microscope and its Revelations" (Carpenter), edited by Dr. Dallinger.

C. F. Higson.—Amœba are somewhat casual in their occurrence, and can frequently be found in non-running water and on mud. No doubt your difficulty in collecting them is due to your failure to distinguish them ; they are somewhat difficult to recognise to those who are unfamiliar with them. The method of mounting the Hydrozoa will be to wash well first in fresh water ; then place in a shallow white dish or saucer, select and cut off the portion that is to be mounted, and place it on a slide slightly warmed ; drain away as much water as possible, and add some glycerine jelly. Apply the cover-glass, allow the slide to cool, remove the excess of jelly around the edge of the cover, wash the slide in water, dry, and add several coats of enamel or varnish.

Communications and enquiries on Microscopical matters are cordially invited, and should be addressed to F. SHILLINGTON SCALES, KNOWLEDGE *Office*, 326, *High Holborn, W.C.*

NOTES ON COMETS AND METEORS.

By W. F. DENNING, F.R.A.S.

PERIODICAL COMETS.—Of the seven periodical comets which were expected to return to perihelion in 1903, only one (Brooks's comet of 1889 and 1896) appears to have been re-observed This is a disappointing result, but due to conditions which could not be overcome. In 1904 several of the best-known comets of short period will return, and the circumstances will be favourable in two cases. In the early part of the year Pons-Winnecke's and D'Arrest's comets are due, Tempel's of 1873 should visibly return in June, while Encke's will probably be well observed in the autumn. The latter has returned twenty-five times subsequently to its detection by Pons in 1819, and it has been observed on every occasion. At intervals of thirty-three years (= 10 periods) this comet returns at nearly the same times of the year as before, and traverses approximately the same path in the sky ; thus in 1904 the favourable returns of 1805, 1838 and 1871 will be repeated. Mechain was the first to discover this interesting comet, and its mean periodic time derived from thirty-five returns between 1786, January 30, and 1901, September 15, is = 1206·6 days.

GIACOBINI'S COMET (1896 V.).—This comet, which passed its perihelion last June, is possibly visible in large instruments, though its rediscovery has not yet been announced. Its place is computed as R.A. 3h. 20m. 42s., Dec. + 3° 49′, on December 7, and R.A. 3h. 17m. 22s., Dec. + 3° 48′, on December 15. The object will therefore be nearly stationary on the eastern border of the head of Cetus.

COMET 1894 I. (DENNING).—Dr. P. Gast has published in the *Mitteilungen* of the Heidleberg Observatory a summary of the observations and calculations relating to this comet, and gives the positions, ascertained in 1902, of 88 comparison stars lying near its track. The data collected will be valuable in the final determination of the orbit. The comet should return under favourable conditions in the winter following 1908.

OCTOBER METEORS.—Stormy weather and cloudy skies have continued to prevail, so that few opportunities have been presented for any kind of astronomical observation. Fortunately, however, the nights from October 22-25 were generally clear at Bristol, and 74 meteors were observed during nine hours of watching. Amongst these were 14 ζ Geminids (99° + 13°) and 10 Orionids (93° + 16°). The results are somewhat noteworthy as proving what the writer observed in 1900 and 1901, that the ζ Geminids appear to have supplanted the Orionids as the richest shower of the period. Among the contemporary systems, the most active this year were situated at 91° + 59°, 117° + 46° and 128° + 33° (swift meteors), and at 29° + 36°, 32° + 19°, 40° + 21° (slow meteors).

DOUBLY-OBSERVED METEOR.—A fine meteor directed from a radiant close to ε Arietis, was observed by Mr. C. L. Brook. at Meltham, near Huddersfield, and by the writer at Bristol, on October 23, 11h. 47½m. As seen from Meltham, the object crossed the equator in Pisces, the apparent path being from 3° + 3° to 346° − 4°. As viewed from Bristol, it shot through Draco and passed over η in that constellation as it descended almost vertically in the N.N.W. sky. The height of the meteor was 75 miles when first seen over a point near Knighton, Radnorshire, and 37 miles at disappearance over the district of Llanfair, Montgomeryshire. Its length of path was 48 miles, and the earth point is indicated 10 miles S.W. of Denbigh. The shower of Arietids, from which the meteor was directed, forms one of the principal displays in October, and it is one which yields an abundance of fireballs. At Bristol, in 1877, October 28 to November 1, 31 meteors were recorded from a radiant at 43° + 22°, and in 1887, October 11-24, 45 meteors were noted from a centre at 40° + 20°.

FIREBALL.—On November 3rd, 6h 25m. p.m., Mr. C. Grover, of Lyme Regis, observed a large fireball suddenly light up the landscape with a brilliancy equal to that of the full moon. A bright fragment, of the apparent size of Jupiter, detached itself from the principal mass and descended vertically about two degrees west of λ Aquilæ. The same fireball was seen by Mr. A. F. Parbury, of Hascombe, Surrey, in the S.W., and he describes it as a long train of fire, vertical, and near the horizon. It was also witnessed by a correspondent of the *Standard* signing himself "W. D. F.," who says that as he was crossing the Purbeck Hills, Dorset, he saw a very brilliant meteor in the S.W. It fell diagonally from left to right, and disappeared at about 40 degrees above the horizon. "The shape suggested an incandescent tadpole diving from the stars." This fireball was situated over the English Channel, between Lands End and Brest, on the west coast of France, but the observations are not sufficiently exact to permit the real path to be calculated.

BRIGHT METEOR.—A meteor rivalling Jupiter in brilliancy was seen by Mr. H. Macpherson, junior, of Johnsburn, Midlothian, on November 7, 7h. 10m. p m It passed from near Altair to near Alpha Ophiuchi, emitting a blue light, and lasting only a few seconds.

DECEMBER GEMINIDS.—The return of this annual shower should be looked for on the nights December 11, 12, and 13. The moon will be past the last quarter, rising after midnight, and will offer little impediment. The radiant point, like that of the Perseids, probably has a motion eastwards, but sufficient observations have not yet been obtained to render the fact certain.

THE LEONIDS OF 1903.—The Leonid shower formed quite a striking display as observed at Bristol during the morning hours of November 16. The maximum appears to have occurred between 5h. 30m. and 5h. 45m. a.m., when Leonids were falling at the rate of about 170 per hour for one observer. Several fine meteors as brilliant as Jupiter or Venus were seen, and the radiant formed an area of several degrees round the central point, 151° + 22°.

THE FACE OF THE SKY FOR DECEMBER.

By W. SHACKLETON, F.R.A.S.

THE SUN.—On the 1st the sun rises at 7.44 and sets at 3.53; on the 31st he rises at 8.8 and sets at 3.57. Sunspots may now be observed at any time, for the sun appears well on the way to the period of maximum activity. There have been of late rarely less than three groups of spots on the solar disc. During these periods of remarkable solar outbursts and magnetic disturbances, auroræ should be looked for in the north. The sun enters the

sign of Capricornus on the 23rd at 0h. when winter commences.

The Moon:—

		Phases.	H. M.
Dec. 4	○	Full Moon	6 13 P.M.
,, 11	☾	Last Quarter	10 53 A.M.
,, 18	●	New Moon	9 26 P.M.
,, 27	☽	First Quarter	2 23 A.M.

The moon is in perigee on the 7th, and in apogee on the 23rd.

Occultations.—The details of the occultations of the brighter stars visible at Greenwich are as follow:—

Date.	Star Name.	Magnitude.	Disappearance.			Reappearance.			Moon's Age.
			Mean Time.	Angle from N. Point.	Angle from Vertex.	Mean Time.	Angle from N. Point.	Angle from Vertex.	
			h. m.	°	°	h. m.	°	°	d. h
Dec. 4	B.A.C. 1526	5·8	8 53 P.M.	111	148	9 51 P.M.	229	259	15 16
,, 7	λ Geminorum	3·6	5 40 A.M.	109	71	6 41 A.M.	274	233	18 0
,, 11	d Leonis	5·0	1 14 A.M.	168	205	1 46 A.M.	230	265	21 20
,, 31	75 Tauri	5·3	8 24 P.M.	133	154	9 7 P.M.	204	215	12 23

The Planets.—Mercury is an evening star in Capricornus, setting shortly after the sun at the beginning of the month. Towards the end of the mouth he is approaching greatest elongation, and sets in the south-west about $1\frac{1}{2}$ hours after the sun, but even then the elongation is not a favourable one for easy observation.

Venus rises about four hours in advance of the sun, and is best observed during this time. The phase of the planet is gibbous, rather more than half of the disc being illuminated, whilst the diameter of the planet has decreased to about 20″. Increasing distance from the earth, together with greater southerly declination, are rapidly diminishing her brilliancy.

Mars is low down in the south-west, and badly placed for observation, in addition to being very faint; he sets about three hours after the sun.

Jupiter is in quadrature on the 7th, hence about this time he is on the meridian near 6 P.M. The distance of the planet from the earth is increasing, consequently his lustre is diminishing. About the middle of the mouth the polar and equatorial diameters of the planet are 37″·5 and 40″·1 respectively.

The configurations of the satellites as seen in an inverting telescope at 7 P.M. are as follow:—

Day.	West.	East.	Day.	West.	East.
1	1 ○	2 3 4	17	3 2 1 ○	4
2	3 ○	1 $\substack{4\\2}$	18	3 2 ⊙	4
3	3 2 4 ○	●	19	3 ○	1 4 2
4	$\substack{4\\3}$ $\substack{1\\2}$ ○		20	4 1 ○	2 3
5	4 3 ○	1 2	21	4 2 ○	1 3
6	4 1 ○	2 3	22	4 1 ○	3 ●
7	4 2 ○	1 3	23	4 ○	3 1 2
8	4 1 ○	2 3	24	4 3 $\substack{1\\2}$ ○	
9	4 3 ○	1 2	25	4 3 2 ○	1
10	3 4 2 ○	●	26	4 3 ○	2 ●
11	3 2 $\substack{4\\1}$ ○		27	4 1 ○	3 2
12	3 ○	1 $\substack{2\\4}$	28	2 ○	4 1 3
13	1 ○	2 3 4	29	1 2 ○	4 3
14	2 ○	1 3 4	30	○	3 1 2 4
15	1 ○	3 4 ●	31	3 1 ⊙	4
16	3 ○	1 2 4			

The circle (○) represents Jupiter; ⊙ signifies that the satellite is on the disc; ● signifies that the satellite is behind the disc, or in the shadow. The numbers are the numbers of the satellites.

Saturn is in conjunction with Mars on the 21st, and like that planet is too low down in the south-west to be easy of observation.

Uranus is in conjunction with the sun on the 18th, and therefore unobservable.

Neptune is near μ Geminorum, their respective positions on the 15th being:—

	Right Ascension.	Declination N.
Neptune ...	6h. 21m. 7s. ...	22° 16′ 23″
μ Geminorum ..	6h. 17m. 11s. ...	22° 33′ 37″

The chart given in the January number shows his position with reference to the surrounding stars. The planet is in opposition on the 27th, hence about this time he souths near midnight.

The Stars.—The positions of the principal constellations near the middle of the month at 9 P.M. are as follow:—

Zenith . Perseus, Cassiopeia.

South . Andromeda, Aries, Pleiades, Cetus; to the S.W., Pisces; to the S E., Taurus, Orion, *Sirius* rising.

West . Delphinus, Cygnus, Pegasus; Lyra to the N.W.

East . Auriga high up, Canis Minor (*Procyon*); Leo rising in the N.E.

North . Ursa Major, Ursa Minor, Cepheus, Draco.

Minima of Algol occur at convenient times on the 3rd at 6.44 P.M., 20th at 11.38 P.M., 23rd at 8.27 P.M., and 26th at 5.16 P.M.

Chess Column.

By C. D. Locock, B.A.

Communications for this column should be addressed to C. D. Locock, Knowledge Office, 326, High Holborn, and be posted by the 10th of each month.

Solutions of November Problems (J. W. Abbot).

No. 1.

Author's Key.—1. B to R3.

[There is a second solution by 1. K to B3.]

No. 2.

Key-move—1. Kt to Q4.

If 1. . . .	P to B6,	2. Kt × P.
1. . . .	K × Kt,	2. P to B3ch.
1. . . .	K to Kt3,	2. R × Pch.

Solutions received from "Alpha," 4, 4; W. Nash, 4, 4; G. A. Forde (Major), 4, 4; "Looker-on," 6, 4; W. H. S M., 4, 0; G. W. Middleton, 4, 4; "Quidam," 6, 4; J. W. Dixon, 4, 4; C. Johnston, 6, 4; H. F. Culmer, 4, 4; T. Dale, 4, 4; H. S. Brandreth, 4 (No. 1 only).

As the result of this month's problems, "Looker-on" and C. Johnston at present tie for first place, closely followed by Messrs. Nash and Dixon.

W. H. S. M.—R to R6 is a good "try" in No. 2, but appears to be defeated by 1. . . . K to Kt5, and if 2. Kt to Q2 (as you give), K to B4.

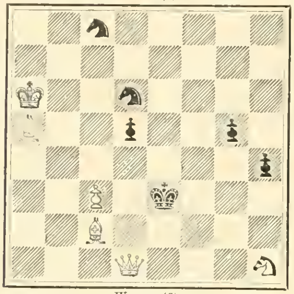
Special Notice.—Will all correspondents kindly note that until further notice all communications should be addressed to C. D. Locock, at the office of Knowledge, 326, High Holborn, London.

PROBLEMS.

No. 1.

By W. Geary.

BLACK (6).



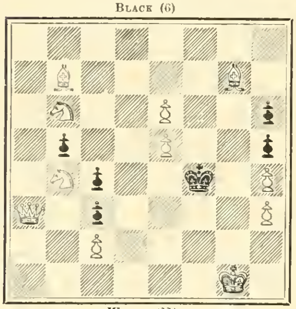
WHITE (6).

White mates in three moves.

No. 2.

By C. D. Locock.

BLACK (6)



WHITE (11)

White mates in three moves.

CHESS INTELLIGENCE.

In the Southern Counties' Championship, Sussex have defeated Hampshire by 10 games to 6, and have lost to Kent by 11½ to 4½.

A match for the World's Championship has been arranged between Dr. Lasker and Dr. Tarrasch, the contest to take place next autumn and the stakes to be £400 a side. The time-limit is unusually generous—14 moves an hour, and the match will be decided in favour of the player who first wins eight games, drawn games not counting. One novel feature of the conditions is the stipulation that each player shall write notes to every game, independently of the other, immediately after its conclusion This will enable the book of the match games to be published almost immediately after the conclusion of the match; a further advantage being that the players will write their notes while the games are still fresh in their memories. The scene or scenes of the encounter will depend on the result of negotiations which Dr. Lasker has been empowered to conduct.

An International Tourney will be held next April at Cambridge Springs, Pennsylvania. Sixteen players, half of them Americans, have already been selected. The contest will be limited to one round.

Game played in the Amateur Championship Tourney at Plymouth.

Queen's Gambit Declined.

WHITE. (A. Emery.)	BLACK. (J. Mortimer.)
1. P to Q4	1. P to Q4
2. P to QB4	2. P to K3
3. Kt to QB3	3. Kt to KB3
4. B to Kt5	4. B to K2
5. P to K3	5. Castles
6. Kt to B3	6. Kt to K5
7. B to B4	7. P to QB3
8. B to Q3	8. P to KB4
9. P to KR4	9. Q to R4 (*a*)
10. B × Kt	10. BP × B
11. Kt to Kt5	11. R to B4 (*b*)
12. Q to R5	12. P to KR3
13. Q to K8ch	13. B to Bsq
14. Q × QB	14. P × Kt
15. Q × KPch	15. R to B2
16. P × KtP	16. B to Kt5 (*c*)
17. P to Kt6	17. B × Ktch
18. K to K2	18. Resigns.

NOTES.

(*a*) An unprofitable excursion. The Queen's Knight should be developed.

(*b*) Evidently inferior. Kt to Q2 being now impossible, there is probably nothing better than P × P, with a view to bringing the Queen across the board to the defence of the King's side.

(*c*) Mere desperation; but if 16. . . . P to Kt3, White wins easily by 17. R to R8ch, K × R; 18. Q × R, B to Kt2; 19. K to K2. Mr. Emery has played the game with great vigour, but Mr. Mortimer was evidently below his usual form.

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